ONTARIO TEACHERS' MANUALS

NATURE STUDY

AUTHORIZED BY
THE MINISTER OF EDUCATION

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TORONTO
WILLIAM BRIGGS

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WILLIAM BRIGGS

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PREFATORY NOTE

This Manual is placed in the hands of the teachers in the hope that the suggestions which it contains on lesson topics, materials, books of reference, and methods in teaching will be found helpful to all teachers and in particular to those who have had little or no instruction in Nature Study during their academic or professional training.

The first Chapter of the Manual discusses topics which have general reference to the subject as a whole. The remaining part of the Manual deals more particularly with the subject in its application to the different Public and Separate School Forms. While this division of the matter into Forms is convenient for general classification, it is not to be regarded as arbitrary. Materials and methods of presentation suitable for one class of pupils in a certain Form might, under different conditions, be quite unsuitable for another class of pupils in the same Form. For example, work which would be suitable for a class in Form I made up of pupils admitted to a school at seven or eight years of age, after two years' training in a kindergarten where nature lessons received special attention, would not be suitable for a Form I class made up of pupils admitted to a school at five years of age with no such previous training. In selecting work for any class the teacher, therefore, should not be guided solely by the arbitrary divisions of the Manual, but should exercise his own judgment, taking into account his environment and the attainments of his pupils. To facilitate such a selection, page references are given in the details of the Course of Study, which in reality forms a detailed expansion of the Public and Separate School Course in Nature Study. By means of these references, the teacher may find, in any department of the subject, typical matter suited to the development of his pupils.

The numerous type lessons that are contained in the Manual are intended to suggest principles of method that are to be applied in lessons upon the same and similar topics, but the teacher is cautioned against attempting to imitate these lessons. This error can be avoided by the teacher's careful preparation of the lesson. This preparation should include the careful study of the concrete materials that are to be used. The books, bulletins, etc., that are named in the Manual as references will be found helpful.

To facilitate teaching through the experimental and investigation methods, special attention has been given to the improvising of simple apparatus from materials within the reach of every teacher.

From the character of the subject the Course of Study must be more or less elastic, and the topics detailed in the programme are intended to be suggestive rather than prescriptive. It may be that, owing to local conditions, topics not named are among the best that can be used, but all substitutions and changes should be made a subject of consultation with the Inspector. The treatment of the subject must always be suited to the age and experience of the pupils, to the seasons of the year, accessibility of materials, etc. Notes should not be dictated by the teacher. Mere information, whether from book, written note, or teacher, is not Nature Study. The acquisition of knowledge must be made secondary to awakening and maintaining the pupil's interest in nature and to training him to habits of observation and investigation.

As a guide to the minimum of work required, it is suggested that at least one lesson be taught from the subjects outlined under each general heading in the detailed Course of Study, with a minimum average of three lessons from the subjects under each general heading.

PUBLIC AND SEPARATE SCHOOL COURSE OF STUDY

DETAILS

FORM I

AUTUMN

GARDEN WORK AND GARDEN STUDIES:

Division of the garden plots, removal of weeds and observations on these weeds, identification of garden plants, observation lessons based on garden plants, selection of seeds, harvesting and disposing of the crop. (See pp. 54-9.)

STUDY OF PLANTS:

Class lessons based on a flowering garden plant, as pansy, aster, nasturtium; study of a field plant, as buttercup, goldenrod, dandelion. (See pp. 55-9.)

Potted and garden plants: Observation lesson based on a bulb; planting bulbs in pots, or in the garden. (See pp. 69-71.)

BIRDS AND CONSPICUOUS INSECTS:

Identification of a few common birds, as robin, English sparrow, meadow-lark; observation lessons on the habits of these birds; collection of the adult forms, the larvæ and the cocoons of a few common moths and butterflies, as emperor-moth, promothea moth, eastern swallow-tail butterfly. (See pp. 30-9 and 93-8.)

COMMON TREES:

Identification of a few common trees, as white pine, elm, maple; observations on the general shape, branches, leaves, and bark of these trees. (See pp. 62-7 and 79-82.)

WINTER

FARM ANIMALS, INCLUDING FOWLS:

Habits and characteristics of a few domestic animals, as horse, cow, sheep, hen, duck; the uses of these animals, and how to take care of them. (See pp. 83-6.)

PET ANIMALS:

Observations on the habits, movements, and characteristics of pet animals, as cat, pigeon, bantam, rabbit, etc.; conversations about the natural homes and habits of these animals, and inferences upon their care. (See pp. 72-7.)

COMMON TREES:

Observations on the branching of common trees. (See pp. 79-82.)

SPRING

GARDEN WORK:

Preparation, planting, and care of the garden plot; observations on the growing plants. (See pp. 87-90.)

FLOWERS:

Identification and study of a few spring flowers, as trillium, bloodroot, hepatica, spring-beauty. (See pp. 90-2.)

BIRDS AND INSECTS:

Identification and study of the habits of a few common birds, as song-sparrow, blue-bird, wren; observations of the form and habits of a few common insects, as house-fly, dragon-fly. (See pp. 30-3 and 93-9.)

COMMON TREES:

Observations on the opening buds of the trees which were studied in the Autumn. (See p. 65.)

FORM II

AUTUMN

BIRDS AND INSECTS:

Autumn migration of birds; identification and observations on the habits and movements of a few common insects, including their larval forms, as grasshopper, eastern swallow-tail butterfly. (See pp. 113-4 and 118-9.)

ANIMALS OF THE FARM, FIELD, AND WOOD:

Observations on the homes and habits of wild animals, as frog, toad, squirrel, ground-hog; habits and structures, including adaptive features, of domestic animals, as dog, cat, horse, cow. (See pp. 83 and 123-30.)

TREES OF THE FARM, ROADSIDE, WOOD, AND ORCHARD:

Observations on the shapes, sizes, rate of growth, and usefulness of common orchard, shade, and forest trees, as apple, elm, horse-chestnut. (See pp. 109-10.)

Wild Flowers and Weeds:

Identification and study of a few common weeds, noting their means of persistence and dispersal. (See pp. 139-40.)

Care of Potted and Garden Plants:

Preparation of pots and garden beds for bulbs; selecting and storing garden seeds; observations on the habits of climbing plants, and application of the knowledge gained to the care required for these plants. (See pp. 101-9 and 120.)

WINTER

Birds:

Identification of winter birds and study of their means of protection and of obtaining food. (See pp. 130-2.)

Animals of the Farm:

Comparative study of the horse and cow, of the dog and cat, and of the duck and hen. (See pp. 123-8.)

Animals of the Park and Zoological Garden:

Observations on the general structural features, noting the natural adaptations of such animals as bear, lion, deer, tiger, etc. (See p. 132.)

Trees:

Winter study of trees, noting buds, branches, and foliage of spruce, cedar, horse-chestnut, etc. (See pp. 121-3.)

SPRING

Birds and Insects:

Observations on the structure, adaptations, and

development of insect larvæ kept in an aquarium, as larva of mosquito, dragon-fly, caddice-fly; spring migration of birds. (See pp. 149-153.)

ANIMALS OF THE FIELD AND WOODS:

Observations on the forms, homes, habits, and foods of wild animals, continued. (See pp. 114-8, 143-9.)

ORCHARD TREES:

The buds and blossoms of apple, and cherry or plum, observed through the stages up to fruit formation. (See pp. 141-3.)

EXPERIMENTS IN THE GERMINATION OF SEEDS:

Germination of seeds and general observations on the stages of development; testing the conditions required for seed germination; introductory exercises in soil study as a preparation for seed planting. (See pp. 133-8 and 112-3.)

WILD FLOWERS AND WEEDS:

Field and class-room study of marsh marigold, Jack-in-the-pulpit, violet, etc. (See pp. 139-40.)

FORM III

AUTUMN

BIRDS AND INSECTS:

Observations on the habits and the ravages of common noxious insects, as cabbage-worm, grasshopper, tussock-moth, etc.; discussion of means of checking these insects. (See pp. 156-7 and 172-7.)

FARM AND WILD ANIMALS OF THE LOCALITY:

Field study and class-room lessons on the habits and structure, including adaptive features, of common

animals, as musk-rat, fox, fish, sheep. (See pp. 99 and 183-5.)

GARDEN AND EXPERIMENTAL PLOTS:

Harvesting of garden and field crops; preparation of cuttings from geraniums, begonia, currant, etc.; identification of garden plants; seed dispersal. (See pp. 154, 179-80, and 164-8.)

STUDY OF COMMON FLOWERS, TREES, AND FRUITS:

Characteristics of annuals, biennials, and perennials; life histories of common plants, as sweet-pea, Indian corn, etc. (See pp. 158-64 and 168-70.)

STUDY OF WEEDS AND THEIR ERADICATION:

Identification of the common noxious weeds of the locality; collection, description, and identification of weed seeds; cause of the prevalence of the weeds studied, and means of checking them. (See pp. 164-8 and 170-2.)

WINTER

FARM AND WILD ANIMALS OF THE LOCALITY:

Habits and instincts of common domestic animals, as fowls, sheep, and hogs; the economic values of these animals. (See pp. 185-8.)

GARDEN WORK AND EXPERIMENTAL PLOTS:

The characteristics of common house plants, and care of these plants. (See pp. 178-9.)

STUDY OF COMMON FLOWERS, TREES, AND FRUITS:

Comparative study of common evergreens, as balsam, spruce, hemlock, etc.; collection of wood specimens. (See pp. 181-3.)

OBSERVATIONS OF NATURAL PHENOMENA:

Simple experiments to show the nature of solids, liquids, and gases. (See pp. 188-9.)

HEAT PHENOMENA:

Source of heat, changes of volume in solids, liquids, and gases, accompanying changes in temperature; heat transmission; the thermometer and its uses. (See pp. 189-200.)

SPRING

BIRDS AND INSECTS:

Field and class lessons on the habits, movements, and foods of common birds, as crow, woodpecker, kingbird, phoebe, blackbird, etc. (See pp. 217-22.)

GARDEN WORK AND EXPERIMENTAL PLOTS:

Care of garden plots; transplanting; testing best varieties; making of, and caring for, window boxes; propagation of plants by budding, cuttings, and layering. (See pp. 201-3 and 208-13.)

COMMON WILD FLOWERS:

Field lessons on the habitat of common wild flowers; class-room study of the plant organs including floral organs; study of weeds and weed seeds continued, also the study of garden and field annuals, biennials, and perennials. (See Autumn.) (See pp. 170-2 and 212-5.)

SOIL STUDIES AND EXPERIMENTS:

The components of soils, their origin, properties, and especially their water absorbing and retaining properties; the relation of soils to plant growth; experiments demonstrating the benefits of mulching and of drainage. (See pp. 203-6.)

FORM IV

AUTUMN

INJURIOUS AND BENEFICIAL INSECTS AND BIRDS:

Identification of common insects and observations on their habits; means of combating such insects, as codling moth, etc.; bird identification, and study of typical members of some common families, as woodpeckers, fly-catchers; spiders. (See pp. 217-22 and 240-5.)

ORNAMENTAL AND EXPERIMENTAL GARDEN PLOTS:

Observations and conclusions based upon experimental plots; common shrubs, vines, and trees, and how to grow them. (See pp. 225-30 and 279.)

FUNCTIONS OF PLANT ORGANS:

Simple experiments illustrating roots as organs of absorption, stems as organs of transmission, and leaves as organs of respiration, transpiration, and food building. (See pp. 273-8.)

ECONOMIC STUDY OF PLANTS:

Comparative study of varieties of winter apples, of fall apples, or of other fruits of the locality; visits to orchards; weed studies continued. (See Form III.) (See pp. 229-30 and 239-40.)

RELATION OF SOIL AND SOIL TILLAGE TO FARM CROPS:

Soil-forming agents, as running water, ice, frost, heat, wind, plants, and animals, and inferences as to methods of tillage. (See pp. 268-70.)

WINTER

AIR AND LIQUID PRESSURE:

Simple illustrations of the buoyancy of liquids and of air; simple tests to demonstrate that air fills space and exerts pressure; the application of air pressure in the barometer, the common pump, the bicycle tire, etc. (See pp. 248-52.)

OXYGEN AND CARBON DIOXIDE:

Generate each of these gases and test for properties, as colour, odour, combustion, action with lime-water; the place occupied by these gases in nature. (See pp. 252-5.)

PRACTICAL APPLICATION OF HEAT, STEAM, AND ELECTRICITY:

Making a simple voltaic cell, an electro-magnet, and a simple electroscope. Test the current by means of the two latter and also with an electric bell. Explain the application of the above in the electric telegraph and motor. Simple demonstration of pressure of steam; history and uses of the steam-engine. (See pp. 259-60.)

SPRING

INJURIOUS AND BENEFICIAL INSECTS AND BIRDS:

Identification of noxious insects and observations thereon; study of representatives of common families of birds, as thrushes, warblers, sparrows; economic values of birds. (See pp. 283-5 and 286-7.)

AQUATIC ANIMALS:

Observation exercises upon the habits, movements,

and structures, including adaptive features of aquatic animals, as crayfish, mussel, tadpole, etc. (See pp. 285-6.)

Ornamental and experimental Garden Plots:

Experimental plots demonstrating the benefits of seed selection; ornamental plots of flowering perennials and bulbous plants; how to improve the school grounds and the home lawns. (See pp. 270-3 and 263-5.)

Tree Studies:

Comparison of the values of the common varieties of shade trees, how to plant and how to take care of shade trees. (See pp. 280-2.)

The Functions of Plant Organs:

Examination of the organs of common flowers; use of root, flower organs, fruit, and seed. (See pp. 273-8.)

Economic Study of Plants:

Plants of the lawn and garden; weed studies. (See pp. 263-5, 270-3, and 278-9.)

Relation of Soil and Soil Tillage to Farm Crops:

Study of subsoils; capillarity in soils; benefits of crop rotations and mulching; experiments in fertilizing, mulching, depth of planting, and closeness of planting. (See pp. 265-7.)

NATURE STUDY

CHAPTER I

THE AIMS OF NATURE STUDY

NATURE Study means primarily the study of natural things and preferably of living things. Like all other subjects, it must justify its position on the school curriculum by proving its power to equip the pupil for the responsibilities of citizenship. That citizen is best prepared for life who lives in most sympathetic and intelligent relation to his environment, and it is the primary aim of Nature Study to maintain the bond of interest which unites the child's life to the objects and phenomena which surround him. To this end it is necessary to adapt the teaching, in matter and method, to the conditions of the child's life, that he may learn to understand the secrets of nature and be the better able to control and utilize the forces of his natural environment.

At all times, the teacher must keep in mind the fact that it is not the quantity of matter taught but the interest aroused and the spirit of investigation fostered, together with carefulness and thoroughness, which are the important ends to be sought. With a mind trained to experiment and stimulated by a glimpse into nature's secrets, the worker finds in his labour a scientific interest that lifts it above drudgery, while, from a fuller understanding of the forces

which he must combat or with which he must co-operate, he reaps better rewards for his labours.

The claims of Nature Study to an educative value are based not upon a desire to displace conventional education, but to supplement it, and to lay a foundation for subsequent reading. Constant exercise of the senses strengthens these sources of information and develops alertness, and at the same time the child is kept on familiar ground—the world of realities. It is for these reasons that Nature Study is frequently defined as "The Natural Method of Study". Independent observation and inference should be encouraged to the fullest degree, for one of the most important, though one of the rarer accomplishments of the modern intellect, is to think independently and to avoid the easier mode of accepting the opinions of others. Reading from nature books, the study of pictures, and other such matter, is not Nature Study. These may supplement Nature Study, but must not displace the actual vitalizing contact between the child and natural objects and forces.

It is this contact which is at the basis of clear, definite knowledge; and clearness of thought and a feeling of at-homeness with the subject is conducive to clearness and freedom of expression. The Nature Study lesson should therefore be used as a basis for language lessons.

Undoubtedly one of the most important educative values that can be claimed for Nature Study is its influence in training the pupil to appreciate natural objects and phenomena. This implies the widening and enriching of human interests through nurturing the innate tendency of the child to love the fields and woods and birds; the checking of the selfish and destructive impulses by leading him to see the usefulness of each creature, the harmony of its relation to its environment, and the significance of

its every part. Nor is it a mistake to cultivate the more sentimental love of nature which belongs to the artist and the poet. John Ruskin emphasizes this value in these words: "All other efforts are futile unless you have taught the children to love trees and birds and flowers".

GENERAL METHODS IN NATURE STUDY

CONCRETE MATERIAL

It is evident that concrete material must be provided and so distributed that each member of the class will have a direct opportunity to exercise his senses, and, from his observations, to deduce inferences and form judgments. The objects chosen should be mainly from the common things of the locality. The teacher should be guided in the selection by the interests of the pupils, first finding out from them the things upon which they are expending their wonder and inquiry. Trees, field crops, flowers, birds, animals of the parks, woods, or farmyard, all form suitable subjects for study.

TOPICS AND MATERIAL MUST SUIT THE SEASON

The material should be selected not only with reference to locality but also with due regard to season. For example, better Nature Study lessons can be taught on the elm tree of the school grounds than on the giant Douglas fir of British Columbia; and on the oriole whose nest is in the elm tree than on the eagle portrayed in Roberts' animal stories; and it is manifestly unwise to teach lessons on snow in summer, or on flowers and ants in winter.

MATTER MUST BE SUITED TO THE CHILD

For the urban pupil the treatment of the material must be different from that in the case of the pupil of the rural school. Rural school pupils have already formed an extensive acquaintance with many plants and animals which are entirely unknown to the children of the city. The simpler facts which are interesting and instructive to the pupils of the urban classes would prove commonplace and trivial to rural pupils. For example, while it is necessary to show the city child a squirrel that he may learn the size, colour, and general appearance of the animal, the efforts of the pupil of the rural school should be directed to the discovery of the less evident facts of squirrel life.

USE OF THE COMMONPLACE

It must be kept in mind that besides leading the pupils to discover new sources of interest, the teacher should strive to accomplish that which is even greater, namely, to lead them to discover new truth and new beauty in old, familiar objects. It may be true that "familiarity breeds contempt" and there is always a danger that the objects with which children have associated in early life may be passed by as uninteresting while they go in search of something "new and interesting".

For example, to be able to recognize many plants and to call them by name is no doubt something of an accomplishment, but it should not be the chief aim of the teacher in conducting Nature Study lessons on plants. It is of much greater importance that the child should be led to love the flowers and to appreciate their beauty and their utility. Such appreciation will result in the desire to protect and to produce fine flowers and useful plants,

and this end can be reached only through intelligent acquaintanceship. There can be no true appreciation without knowledge, and this the child gets chiefly by personal observation and experiment. With reference to the wild flowers of the woods and fields, the method employed is that of continuous observation.

ORDER OF DEVELOPMENT OF THE LESSON

Each animal or plant should be studied as a living, active organism. The attention of the pupils should be focused upon activities; for these appeal to the child nature and afford the best means for securing interest and attention. What does this animal do? How does it do it? How is it fitted for doing this? How does this plant grow? What fits it for growing in this way? These are questions which should exercise the mind of the child. They are questions natural in the spirit of inquiry in child nature and give vitality to nature teaching. They are an effective means of establishing a bond of sympathy between the child and nature. The child who takes care of a plant or animal because it is his own, does so at first from a purely personal motive, which is perfectly natural to childhood; but while he studies its needs and observes its movements and changes, gradually and unconsciously this interest will be transferred to the plant or animal for its own sake. The nature of the child is thus broadened during the process.

PROBLEMS IN OBSERVATION

In studying the material provided, whether it be in the class-room, or during a nature excursion, or by observations made in the farmyard at home, the teacher must guide the efforts of the pupils by assigning to them definite and suit-

able problems. Care must be taken to reach the happy mean of giving specific directions without depriving the pupils of the pleasure of making original discovery. For example, instead of asking them to study the foot of the horse and learn all they can about it, more specific problems should be assigned, such as: Observe how the hoof is placed on the ground in walking. What are the arrangements for lessening the shock when the hoof strikes the ground? Examine the under surface of the hoof and discover what prevents the unshod horse from slipping.

NOTE-BOOKS AND RECORDS

In Grades higher than Form I, written exercises should be required and also sketches representing the objects studied. For this purpose a Nature Study note-book is necessary—a loose-leaf note-book being preferable because of necessary corrections, rearrangements, additions, or omissions.

In all records and reports, independence of thought and of expression should be encouraged. The drawing and the oral or written description should express what is actually observed, not what the book or some member of the class says has been, or should be, observed. The descriptions should be in the pupil's own words, because these are most in keeping with his own ideas on the subject. More correct forms of expression may be obtained when notes are taken from the teacher's dictation, but this is fatal to the development of originality.

The disparity of the results in individual work gives opportunity for impressing upon the pupil, in the first place, the necessity for more accurate observation and, secondly, the impossibility of reaching a correct general

conclusion without having studied a large number of examples. The development of critical and judicious minds, which may result from carefully observing many examples and generalizing from these observations, is vastly more important than the memorizing of many facts.

THE SCHOOL GARDEN

In the study of garden plants there is added a certain new interest arising out of experimentation, cultivation, and ownership. The love of the gardener has in it elements that the love of the naturalist does not usually possess—a sort of paternal love and care for the plants produced in his garden; but every gardener should be a naturalist as well. Most people have a higher appreciation for that which they own and which they have produced or acquired at some expense or personal sacrifice; therefore it is that the growing of plants in home and school gardens or in pots and window boxes is so strongly advocated throughout this Course. Ownership always implies responsibility, which is at once the chief safeguard of society and the foundation of citizenship. A careless boy will never respect the property of others so much as when he himself has proprietary interests involved. We believe, therefore, that every teacher should encourage his pupils to cultivate plants and, if possible, to own a plot of ground however small.

The teacher should not merely aim at *making* a garden in the school grounds. The great question is rather how best to use a school garden in connection with the training of boys and girls. To learn to do garden work well is indeed worth while and provides a highly beneficial kind of manual training. To understand something of soils and methods of cultivation, of fertilizers and drainage, the best kinds of flowers, vegetables, fruits, and farm crops, and how

to grow them successfully, is very important in such a great agricultural country as this; but the greatest of all results which we may hope to realize in connection with school gardening is the ennobling of life and character. The pupils are taught to observe the growing plants with great care, noting developments day by day. This adds to their appreciation of the beauties and adaptations found among plants on every side, and cannot fail to produce good results in moral as well as in mental development. The teachers must always remember that the gardeners with whom they are working are more important than the gardens which they cultivate.

The best garden is not always the largest and most elaborate one. It is rather the garden that both teacher and pupils have been most deeply interested in. It is the garden in which they have experienced most pleasure and profit that makes them want to have another better than the last. No school is too small to have a garden of some kind, and no garden is too small to become the joy and pride of some boy or girl.

SUGGESTIONS

For the benefit of teachers beginning their duties on the first of September, in school sections where school gardening has never been carried on, the following suggestions are offered:

1. See if the grounds will permit of a part being used for a garden. To ascertain this, note the size of the present grounds and see if they meet the requirements of the Department as laid down in the Regulations. If they do not, consult your Inspector at once and acquaint him with your plans. If the grounds are to be enlarged, try to take in sufficient land of good quality to make a good garden.

The part chosen for the garden should be both convenient and safe. Examine the soil to see if it is well drained and sufficiently deep to permit of good cultivation. Lack of fertility can be overcome by good fertilizing.

2. See that the fences and gates are in good repair. When circumstances will permit, a woven wire fence that will exclude dogs, pigs, and poultry is most desirable. If not used to inclose the whole grounds, it should at least inclose the part used for gardening.

3. Begin modestly and provide room for extension as the work progresses. Sow clover on the part to be held in reserve for future gardening operations.

4. If local public sentiment is not strongly in favour of school gardening, or is somewhat adverse, begin on a small scale. If the work is well done, you will soon have both moral and financial support.

5. See that the land is well drained. Plough it early in the autumn and, if a load of well-rotted manure is available, spread it on the land before ploughing. Commercial fertilizer may also be used on the plots the following spring, but no stable manure.

6. In spring, when dry enough, cultivate thoroughly with disc and drag harrows. Build up a compost heap in the rear of the garden with sods and stable manure, for use in the autumn and also the following spring.

GARDEN EXPENSES

In connection with those schools where the teacher holds a diploma from the Ontario Agricultural College in Elementary Agriculture and Horticulture, there is no difficulty in meeting the expenses for seeds, tools, fertilizers, and labour, as the Government grant for such purposes is sufficient. In

other schools, however, where the teacher holds no such diploma (and such is the case in most of the schools as yet), other means of meeting the expenses must be resorted to. The following are offered as suggestions along this line:

1. Part of the grant made to every school for the maintaining of the school grounds should be available for school garden expenses.

2. An occasional school entertainment may add funds that could not be used to better advantage.

3. An occasional load of stable manure supplied free from neighbouring farms will help to solve the fertilizer problem.

4. Donations of plants and seeds by the parents and other interested persons and societies will be forthcoming, if the teacher is in earnest and his pupils interested.

5. If it is required, the trustees could make a small grant each year toward the cost of tools.

6. Fencing and cultivation of the garden can often be provided for by volunteer assistance from the men of the school section.

7. It is often possible to grow a garden crop on a fairly large scale, the school being formed into a company for this purpose and the proceeds to be used to meet garden expenses.

8. The pupils can readily bring the necessary tools from home for the first season's work.

9. Many Agricultural and Horticultural societies offer very substantial cash prizes for school garden exhibits, and all funds so obtained should be used to improve the garden from which the exhibits were taken.

10. An earnest, resourceful teacher will *find a way* of meeting the necessary expenses.

THE EXCURSION

Nature Study is essentially an outdoor subject. While it is true that a considerable amount of valuable work may be done in the class-room by the aid of aquaria, insectaria, and window boxes, yet the great book of nature lies outside the school-house walls. The teacher must lead or direct his pupils to that book and help them to read with reverent spirit what is written there by its great Author.

Value.—The school excursion is valuable chiefly because it brings the pupil into close contact with the objects that he is studying, permits him to get his knowledge at first hand, and gives him an opportunity of studying these objects in their natural environment. Incidentally the excursion yields outdoor exercise under the very best conditions—no slight advantage for city children especially; and it gives the teacher a good opportunity to study the pupils from a new standpoint. It also provides a means of gathering Nature Study material.

Difficulties.—Where is the time to be found? How can a large class of children be managed in the woods or fields? If only one class be taken, how, in an ungraded school, are the rest of the children to be employed? Will the excursion not degenerate into a mere outing? What if the woods are miles away? These are all real problems, and the Nature Study teacher, desirous of doing his work well, will have to face some of them at least.

SHORT EXCURSIONS

The excursion need not occupy much time. It should be well planned beforehand. *One* object only should be kept in view and announced to the class before starting.

Matters foreign or subordinate to this should be neglected for the time. The following are suggested as objects for excursions:

Objects.—A bird's nest in an adjacent meadow; a ground-hog's hole; a musk-rat's home; crayfish or clams in the stream near by; a pine (or other) tree; a toad's day-resort; the soil of a field; the pests of a neighbouring orchard; a stone-heap or quarry; ants' nests or earthworms' holes; the weeds of the school yard; buds; the vegetable or animal life of a pond; sounds of spring; tracks in the snow; a spider's web.

Such excursions may be accomplished at the expenditure of very little time. Many of them will take the pupils no farther than the boundaries of the school yard.

Of course the locality will influence the character of the excursion, as it will that of the whole of the work done in Nature Study, but in any place the thoughtful teacher may find material for open-air work at his very door.

Much outside work can be done without interfering with the regular programme. The teacher may arrange a systematic list of questions and problems for the pupils to solve from their own observations, and these observations may be made by the pupils at play hours, or while coming or going from school, or on Saturdays. The following will serve as an example of the treatment that may be followed:

Pests of Apple Trees.—Look on the twigs of your apple trees for little scales. Bring an infected branch to school. Note whether unhealthy-looking or dead branches are infected. Examine scales with a lens. Loosen one, turn it over, and examine with a lens the under side.

For eggs, look closely at the twigs in June. Do you see white specks moving? If so examine them with a lens.

Are there any small, prematurely ripe apples on the ground in the orchard? Cut into one of these and look for a "worm". Look for apples with worm holes in the side. Are there worms in these apples? What is in them? Note the dirty marks that the larva has left. Keep several apples in a close box and watch for the "worms" to come out. Examine the bark of apple trees for pupæ in the fall.

FREQUENCY OF EXCURSIONS

As to the frequency of excursions, the teacher will be the best judge. It is desirable that they occur naturally in the course of the Nature Study work as the need for them arises. One short trip each week with a single object in view is much more satisfactory than a whole afternoon each term spent in aimless wandering about the woods.

EXCURSIONS TO A DISTANCE

Long-distance excursions will of necessity be infrequent. If the woods are far away, one such trip in May or June would prove valuable to enable the pupils to become acquainted with wild flowers, and another in October to gather tree seeds, autumn leaves, pupæ, and other material for winter study. When a large class is to be taken on an excursion, preparations must be made with special care. The teacher and one or two assistants should go over the ground beforehand and arrange for the work to be done. Some work must be given to every pupil, and prompt obedience to every command and signal must be required. The class, for example, may decide to search a small wood or meadow to find out what flowers are there. The pupils should be dispersed throughout the field to hunt for specimens and to meet at a known signal to compare notes.

SUGGESTIONS FOR UNGRADED SCHOOLS

1. The teacher may take all the classes, choosing an object of study from which he can teach lessons suitable to all ages, a bird's nest, for example.

2. In many sections, the little ones are dismissed at 3.30 p.m. Opportunity is thus given for an excursion with the seniors.

3. The older pupils may be assigned work and left in charge of a monitor, elected by themselves, who shall be responsible for their conduct, while the teacher is working outside with the lower Forms.

4. Boys who are naturally interested in outdoor work should be encouraged to show the others anything of interest they may have found.

5. An occasional Saturday excursion may be arranged.

Discipline.—The teacher should insist on making the excursion a serious part of the school work, not merely recreation. School-room behaviour cannot be expected, but the boisterous conduct of the playground should give place to earnest expectancy. The pupils should keep within sound of the teacher's voice (a sharp whistle may be used) and should promptly respond to every call. Topics of conversations should as far as possible be restricted to those pertaining to the object of the excursion or related matters.

In visiting woods, children should be trained to study flowers in their environment and leave them there, plucking or digging for none except for some excellent reason. The same respect should be shown to birds and their nests, and to insects, and all other living things encountered.

THE TEACHER'S EXCURSIONS

As soon as possible after coming to a section, the teacher should acquaint himself with the woods, groves, streams, or other haunts that may provide him with material for his indoor or outdoor work. He can then direct the pupils effectively. The teacher should go over the route of an excursion shortly before it takes place. This prevents waste of time in looking for the objects that he wishes his pupils to see. If the teacher wishes to increase his love for nature, he must take many walks without his pupils.

The school garden offers a partial solution of the difficulties mentioned above. It brings a large amount of material to the doors of the school. Plants of the farm or the garden may be studied under various changeable conditions, and it will be seen that insect pests, weeds, and fungous diseases follow the lessons on plants, while lessons on birds and toads follow those on insects. With sections of the garden devoted to the cultivation of wild flowers, ferns, and forest trees, the specially organized excursion will become less of a necessity, although it will still continue to be a valuable factor in Nature Study work.

After an excursion is over, it should be discussed in class. The various facts learned should be reviewed and related. If any pupils have made inaccurate observations, they should be required to observe again to correct their errors. Finally, the excursion may form the subject of a composition.

A TYPE EXCURSION

A Bird's Nest.—The children have been instructed to study the meadow-lark, beginning about March twenty-first. While engaged in this work, a nest is discovered

near the school. The teacher is informed and the pupils are conducted to the spot.

What is growing in the field? Is there a long or a short growth? Did the mother bird make much noise as she rose from the nest? Did this help to reveal its presence? Is the nest easy to see? The class will halt a few paces from it and try to find it. How many eggs? Their colour? Note the arch of grass so beautifully concealing the nest.

Returning to school, the facts observed are reviewed. The pupils may then express themselves by written composition or by drawings, paintings, or modellings of the nest, the eggs, or the surroundings. Frequent visits to the nest should not be made, and the pupils should be warned not to disturb the bird, as she may desert the nest on slight provocation.

A second excursion may be made, when the eggs are hatched, to see the young birds.

A Wasp's Nest.—A nest having been discovered, the pupils note how it is suspended and how it is situated with regard to concealment or to protection from rain, its colour, the material of the nest, and the position of the entrance. Is the opening ever deserted? How many wasps enter and how many leave the nest in a minute? Try to follow one and watch what he does. Wasps may be found biting wood from an old board fence. This they chew into pulp, and from this pulp their paper is made. Get the children to verify this by observations. If the nest is likely to become a nuisance, smoke out the wasps, take the nest carefully down, and use it for indoor study, examining the inside of the nest to ascertain the nature and the structure of the comb which, in this case, is entirely devoted to larvæ.

COLLECTIONS

General school collections of such objects as noxious weeds, weed seeds, wild flowers, noxious insects, leaves of forest trees, rocks or stones of the locality, etc., should be undertaken.

All the pupils should contribute as many specimens as possible to each collection and should assist in the work of preparing them.

In addition to the above collections it is advisable that pupils who show special interest in this phase of nature work should be encouraged to make individual collections.

Collections, when properly prepared, have a value within themselves, because of the beauty and variety of the forms that they contain, and also because of their usefulness in illustrating nature lessons and in the identifying of insects, weeds, etc. Nevertheless the chief value of the collection rests in the making of it, because of the training that it gives the collector in carefulness and thoroughness, and also because it causes the child to study natural objects in their natural surroundings.

ANIMAL STUDIES

DOMESTIC ANIMALS

The teacher, before attempting to teach lessons on domestic animals, should carefully consider how his lessons will best fulfil the following important aims:

1. The cultivation of a deeper sympathy for, and a more complete understanding of, farm animals.

2. The development of more kindly treatment of domestic animals through awakened sympathy and more intelligent understanding.

3. Implanting the idea that the best varieties are the most interesting and profitable.

The following domestic animals are suggested as being suitable for study: horse, cow, sheep, dog, cat, goose, duck, hen.

There are two practical methods of observation work; namely, home observation and class-room observation.

The observation work on some of the animals named must of necessity be done out of school. In this the teacher can direct the efforts of the pupils by assigning to them definite problems to be solved by their study of the animals.

The results of their observations can be discussed in the class in lessons of ten or fifteen minutes length. It may frequently be necessary to re-assign the problems in order that the pupils may correct their observations.

It is possible for the teacher or the pupils to bring to the school-room certain of the animals, as the dog, cat, duck, hen, and the observations may then be made by the whole class directly under the guidance of the teacher.

REFERENCES

Crawford: *Guide to Nature Study.* Copp Clark Co., 90 cents.

Dearness: *How to Teach the Nature Study Course.* Copp Clark Co., 60 cents.

Shaler: *Domesticated Animals.* Scribners, $2.50.

Smith: *The Uses and Abuses of Domestic Animals.* Jarrold & Sons, 50 cents.

BIRDS

The chief aims in developing lessons on birds are:

1. To teach the children to recognize their bird neighbours, to love them for their beauty, and sweet songs, and their sprightly ways.

2. To train the pupils to appreciate them for their usefulness in destroying insect pests.

Many persons spend their lives surrounded by singing birds, yet they never hear their songs. Many children see and hear the birds, but if they have not been brought into sympathetic relation with them, they never learn to appreciate them; on the contrary, their attitude becomes one of indifference or of destructiveness. Too often, boys cruelly destroy the nests and young and persecute the old birds with stone and catapult. The cowardice of such acts should be condemned, but more effective lessons may be taught through leading the children to find in the birds assistants and companions that contribute to their material progress and to their joy in life.

With these aims in view, the teacher will readily perceive that the most effective work in bird study results from observing the living birds in their natural environment. Field excursions are valuable for this, but good results can seldom be attained when the class is large, for birds are shy and will hide or fly away from the unusual excitement. Quietness is absolutely necessary for success. Better results are obtained when only one or two accompany the teacher. If the teacher selects a few who are interested in birds, and there are always some pupils in every school who are readily interested in bird study, these few can soon be made sufficiently acquainted with the more common birds, so that they will be able to point them out to the other pupils of the school, and thus they become the teacher's assistants in the work.

By beginning with the most common and conspicuous birds, an acquaintance grows rapidly. Early spring is a good time to begin, when the first birds return from their winter sojourn. The teacher and pupils may now learn

to recognize the birds, because there are only a few, and these are easily seen, as the robin, blue-bird, junco, meadow-lark, goldfinch, bronzed grackle, sapsucker, blue jay, downy woodpecker, and flicker.

The teacher, assisted by the pupils who already know these birds, directs the younger pupils to where these birds may be seen, and they are also required to describe the birds observed and to identify them by means of the bird chart or colour key.

The description should include:

Size (compare with some common bird); shape; colour of head, back, and breast; conspicuous markings, as crest, stripes, bright patches of feathers; movements in flight or on the ground; song, call notes; whether in flocks, or pairs, or single birds.

Later in spring, other birds will attract attention, as the song-sparrow, phœbe, wren, horned lark, cowbird, and red-winged blackbird; while in summer the oriole, cat-bird, vesper sparrow, American redstart, night hawk, scarlet tanager, and crested flycatcher are some of the birds that will call for attention, because of their plumage, songs, or peculiar habits.

When a nest has been found by a pupil, he should report it to the teacher, and the other pupils should be permitted to visit it only upon promising not to molest the nest or to annoy the mother bird by remaining too long near it. While it is well that the pupils should see the nest with the young birds, they should be taught to respect the desire of the bird for quietness and seclusion.

In studying the nest, observe: Concealment, protection, size, comfort, number and colour of eggs, young birds, size, colour, covering, food. The pupils should be asked to observe the feeding of birds thus:

Watch the wrens returning to the nest; what do they carry to their young? Where do the wrens get the snails and grubs? Observe how the robins find the worms and how they pull them out of the ground. Follow the downy woodpecker to the apple tree and find out what he was pecking. Watch the crow in the pasture field and learn whether this bird kills grasshoppers and crickets.

Observe the birds that pick seeds out of the weeds.

Collecting birds' eggs should be condemned, because it nearly always leads to the robbing of the nests. The practice of exchanging eggs is the chief cause of this; for although an occasional boy will collect wisely, the greater number are simply anxious to add to their collection without regard for the sacredness of the birds' homes.

A collection of birds' nests may be made after the nests have been abandoned for the season, and it will be found useful for interesting the pupils in the ingenuity, neatness, and instinctive foresight of the builders.

REFERENCES

Chapman and Reed: *Colour Key to North American Birds* $2.75
Reed: *Bird Guide, Pts. I and II* ..... .75
Silcox and Stevenson: *Modern Nature Study* ..... .75
Cornish: *Thirty Lessons in Nature Study on Birds.* Dominion Book Company 1.00

Canadian Birds in Relation to Agriculture. This chart has pictures in colours of eighty-eight Canadian birds. G. M. Hendry Co., $3.00.

The Audubon Charts. These three charts have pictures of fifty-five birds; the pictures are larger in the latter charts than in the first named. G. M. Hendry Co., $2.00 each.

Coloured Bird Pictures, Mumford, Chicago, (separate coloured pictures) are very suitable for illustrating nature lessons on birds.

INSECTS

There are three classes of insects that are of immediate interest to the pupils of the Junior Grades, and the teacher who makes direct use of this natural interest has taken possession of the key to success in insect study in the primary classes.

The three classes, basing the classification upon their power to attract attention, are:

The beautiful insects, including moths, butterflies, and beetles,

The wonderful insects, including such insects as ants, ant-lions, caddice-flies, etc.,

The economic insects, including bees, silk-worms, codling-moths, etc.

Economic insects are interesting because of their relations to the occupations of the home. The successful growing of farm, orchard, and garden crops practically depends upon keeping a proper balance of insect and bird life.

The teacher who feels that his knowledge of insects is too limited to allow him to undertake the teaching of this branch of Nature Study should cast his misgivings aside; for it is not difficult for the teacher who knows nothing about insects at the outset to become acquainted with such members of the three classes named above as attract the attention of the pupils of the Nature Study classes.

The following suggestions in insect study are offered as guides to teacher or pupil:

Obtain books and pamphlets from the Department of Agriculture, Toronto, on the subject of Insect Pests on Farm Crops and Fruit Trees.

Secure a good general book on insects. *Modern Nature Study,* by Silcox and Stevenson, contains illus-

trations of several of the most common moths and butterflies, which are clear enough to make possible the identification of the forms represented. Comstock's *Manual for the Study of Insects* is the best general book on the subject. This, and Holland's *The Moth Book* and *The Butterfly Book,* are valuable for those who wish to follow the study of insects at any length.

Begin by studying the more conspicuous moths, butterflies, and beetles, and especially by studying the injurious forms which thrust themselves into prominence by causing destruction of grain, vegetable, or fruit crops in the locality. The utility phase of lessons on these insects will appeal to the older children and also to their parents. Moreover, these are the easiest insects to identify and upon which to obtain literature dealing with their life histories and habits.

Carefully observe the colour, size, and shape of the insect, and note the plant on which it is feeding and its manner of feeding. Consult available books on plant pests to find descriptions of the insects that feed upon this plant, and study carefully what is said about the insect observed. If this method is persistently followed, the teacher will be surprised at the rapidity with which his acquaintance with insects broadens.

Pictures of moths, butterflies, and beetles are of great assistance in the identification of these insects.

A school collection, made from the insects studied, is useful for future collection and for identification of insects. Do not allow any insect to be killed unless it is a good specimen intended to fill a place in the collection, or unless it is known to be an injurious insect. The teacher, by exercising proper control of the collecting, has an efficient means of teaching the sacredness of life. The fact

should be emphasized that killing even an insect, when there is no good reason for doing so, is the act of a mean and selfish coward.

In addition to a collection of insects, including larval and pupal forms, collections of insect nests, of plant galls, of markings of engraver beetles, of burrows of tree borers, and of samples of the destructive workings of insect pests should be made.

While nothing is more beautiful than a carefully prepared collection of moths, butterflies, and beetles with their infinite variety of form and colour, nothing is more disgusting than a badly preserved collection of distorted, shrivelled, vermin-infested specimens. The teacher should avail himself of the collecting instinct which is prominent in boys of nine to fourteen years of age and of their desire to have things done well, to develop in them habits of carefulness, neatness, and thoroughness.

INSECT COLLECTIONS

See Manual on *Manual Training,* for details for making collecting appliances.

Agricultural Bulletin No. 8, *Nature Collections for Schools,* Department of Education, Ontario, for detailed instructions on making insect collections.

The outfit for collecting is neither expensive nor hard to prepare. It consists of (1) an insect net for catching the insects, made by sewing a bag of cheese-cloth to a stout ring one foot in diameter, which is fastened to a broom handle; (2) a cyanide bottle for killing the insects, prepared by pouring some soft plaster-paris over a few lumps of potassium cyanide (three pieces, each of the size of a pea) in a wide-mouthed bottle. When the plaster has set, keep the bottle tightly corked to retain the poisonous

gases. (3) Pins to mount the specimens. Entomological pins, Nos. 2, 3, and 4, are the best for general use. Beetles are usually pinned through the right wing-cover at about one fourth of its length from the front end of it. Moths and butterflies are pinned through the thorax. Small insects may be fastened to a very small pin, which in turn is set into a bit of cork, supported by a pin of ordinary size. (4) Spreading board for moths and butterflies. (5) Insect boxes to hold the specimens. This should be secured before the collection is begun. It is a common mistake to believe that any box whatever will do for storing insects. It is necessary to encourage effort in drying, spreading, pinning, and labelling, by providing an effective means of permanently preserving the specimens. In cigar-boxes, pasteboard boxes, and such makeshifts, the specimens soon become broken, covered with dust, and marred in other ways, and the collectors become discouraged; hence it is necessary to secure good boxes from dealers in entomological supplies.

A sponge saturated with carbon bisulphide should be placed in the box at intervals of not more than three months, to ensure the killing of parasites that destroy the specimens.

Entomological supplies may be obtained from Chapman & Co., London, Ont., or from G. M. Hendry Co., Toronto, Ont., or from Messrs. Watters Bros., Guelph, Ont.

BUTTERFLY AND MOTH COLLECTIONS

For a study of the metamorphosis of butterflies and moths, it is necessary to have an insect cage. This can be purchased from any dealer in entomological supplies or it may be made by the pupils in the Manual Training Class. See Manual on *Manual Training*. A very satis-

factory cage may be made, by the teacher or larger pupils, from a soap box, by tacking wire gauze over the open surface of the box, removing the nails from one of the boards of the bottom, and converting this board into a door by attaching it in its former position by light hinges and a hook and staple. The box, if now placed on end with two inches of loose soil in the bottom, will constitute a satisfactory insect cage, or vivarium.

A large lamp chimney with gauze tied over the upper end is useful for inclosing a small plant upon which eggs or insect larvæ are developing. The base of the chimney may be thrust an inch into the soil and the development of the larva as it feeds upon the growing plant can be studied.

The following are larvæ suitable for study and may be found in the places named:

The tomato worm on tomato or tobacco plants. (Look for stems whose leaves have been stripped off.)

The milkweed butterfly larvæ on milkweed,

The potato beetle on potato vines,

The eastern swallow-tail butterfly on parsnip or carrot plants,

The tussock-moth on horse-chestnuts,

The promothea moth on lilac bushes,

The cabbage-butterfly on cabbage or mustard plants,

The red-spotted purple, banded purple, and viceroy butterfly larvæ on willow and alder,

Cocoons of tussock-moth and tiger-moth under bark, logs, and rubbish in early autumn.

Larvæ of the emperor-moth (cecropia) may be found wandering about, apparently aimlessly, in September; but they are searching for suitable places for attaching their cocoons to orchard and forest trees.

After the leaves have fallen from shrubs and trees, cocoons can be found more easily on the naked twigs or in withered, rolled-up leaves that are fastened by the silk of the cocoon to the branches.

Larvæ, when placed in the cage, should be supplied with green plant food such as they were found feeding upon, and the pupils should be instructed to observe the chrysalis building or the cocoon weaving. It will be found that some larvæ burrow into the soil.

During winter the cage should be kept in a cool place, such as a shed, so that the winter conditions may be as nearly natural as possible.

In a few cases, the development within the cocoon is quite rapid; and the adult form hatches out in a few weeks, for example, the cabbage-butterfly, monarch or milkweed butterfly, and tussock-moth. For this reason these are preferable for study by Form I pupils. In April the cage should be placed in the school-room, that the pupils may observe the emergence of the insects and the spreading of the wings. The insects can be fed with syrup or honey until they are strong, then the pupils should set them free.

Reference.—*Reports of the Entomological Society of Ontario*, Department of Agriculture.

PLANT COLLECTIONS

The instructions given below for collecting, pressing, and mounting plants are applicable to wild flowers, grains, grasses, and weeds.

The specimen.—Select a plant which in form and size is typical of its species and which is in full flower. Care must be taken to dig down and secure the root.

If the plant is too large for the mounting sheet, cut out the central part, and use the root, lower leaves, upper leaves, and flower. If the root is very thick, cut slices lengthwise off the sides so as to reduce it to a flat form that is not too bulky.

Before the plant has had time to wither, spread it out flat on a sheet of paper and spread another sheet over it, taking care to straighten the leaves and flower out. Blotting-paper is preferable, but any soft paper that will absorb moisture will make a very good substitute.

Pressing and drying.—Place several sheets of paper above and below the specimen. Any number of specimens prepared as described in the last paragraph may be placed in a pile, one over another, resting on the floor or on a table. Place on top of the pile a board which is large enough to cover the surface of the pile, and on the board place a weight of about fifteen pounds of bricks, or other convenient material. A box containing sand, stones, or coal may be used in place of the board and weights. The weight prevents the shrivelling and distortion of the plants.

To prevent discoloration and mildewing of the plants, the papers around them must be changed at the end of the following successive intervals: two days, three days, five days, one week, etc., until they are quite dry. The length of time required for pressing and drying depends upon the quantity of sap in the plants and also upon the dryness or humidity of the atmosphere.

Mounting.—When dry, the specimens are mounted on sheets of heavy white paper. These sheets are cut to a standard size, eleven inches by fourteen inches, or sheets of half this size, namely, seven inches by eleven inches.

are permissible. The best method of attaching the plant to the sheet is by pasting narrow strips of gummed paper across the plant in such positions as will serve to hold all parts of it in position.

Labelling.—The name of the specimen, the date of collection, the place from which collected, and the name of the collector are to be neatly written in a column in the lower right-hand corner of the sheet. Printed labels which are pasted on this corner of the sheet are also used.

Collections of leaves may be prepared by the same process as that given for plants. Leaves will retain their autumn tints if their surface is covered with varnish or paraffin, which will prevent the admission of air.

To cover with paraffin dip the leaf for a moment into melted paraffin.

CHAPTER II

PHYSICAL SCIENCE PHASE OF NATURE STUDY

INSTRUCTIONS AND GENERAL METHOD

THE preceding portions of this Manual dealt with living things. There is another phase of Nature Study which has a more direct relation to the physical sciences, Chemistry and Physics, two subjects that are essentially experimental in their methods.

Although the lessons that follow are grouped in one portion of this book, the teacher should understand that he is to introduce them into his work as the occasion demands. They may be used to throw light on other parts of the school work. The experimental method is somewhat advanced for young children, hence no lessons are outlined for Forms I and II. In ungraded schools, Forms III and IV may be combined for the subject. It will be found most convenient to take this portion of the Nature Study during the winter months.

VALUE OF SUCH LESSONS

1. They are *interesting,* hence there is attention. The senses must be alert, hence pupils are trained to observe accurately.

2. After the experiment comes the inference, hence reasoning powers are developed.

3. They enable the teacher to make exceedingly *concrete* some very difficult abstract principles.

4. They can be *correlated* with a large number of other subjects and made to have a beneficial influence on the whole of the school work.

5. The great advance that is being made in all useful inventions to-day is largely due to the study of the physical sciences. Many boys and girls (seventy-five per cent.) never attend the High School. The Elementary School owes them a taste at least of these sciences that have such a bearing on their lives, that have surrounded them with so many mechanical contrivances for their comfort and convenience, and that explain so many common natural phenomena. Give a boy a taste for experimental science, and there is some chance that after leaving school he will not throw aside his studies to subsist intellectually on the newspaper, but that he will continue to investigate for himself, and make himself a well-informed man, an influential man in his section. The Elementary School must aim at fitting the boys and girls for life.

6. The advent of the experiment marks the downfall of superstition, prejudice, and reliance on authority and tradition. To lead a child to think for himself is a great achievement.

7. The use of the experiment in gaining knowledge will result in a cautiousness in accepting statements and making decisions.

CONDITIONS UNDER WHICH EXPERIMENTS SHOULD BE PERFORMED

1. They should be introduced into the school work naturally, as answers to questions which arise either in the regular course of the work or from suggestions made by the teacher at appropriate times.

2. As far as possible, the pupils should assist in performing the experiment. In small rural schools the scarcity of apparatus will necessitate the teacher's doing most of the work. In Form V classes and Continuation Schools the pupils may do the experiments individually.

3. The bearing of an experiment is not always evident; the teacher must be ready with judicious questions to lead the class to the proper conclusions.

4. The pupils must be acquainted with all the apparatus used. They must know what the teacher is doing and must be near enough to see the result.

5. A problem may be suggested, and a few days allowed for the pupils to think out a means of solution. If they invent and make their own apparatus, so much the better.

6. Whenever possible, the experiment should be applied to some natural phenomenon or everyday occurrence.

CORRELATIONS OF PHYSICAL SCIENCE PHASE

Geography.—The value of Physical Science in the Elementary School is largely due to the light it throws on geographical data. Numerous examples will appear in the succeeding pages.

Hygiene.—Experiments in carbon dioxide, oxygen, air, water, sound, and light, are absolutely necessary, if the children are to grasp with any degree of clearness the principles of respiration and ventilation, and the phenomena of hearing and seeing.

Manual Training.—Many pieces of apparatus may be made by the boys in their work with wood or iron. Some of the elementary principles of chemistry enable the girls to do their cooking intelligently. A knowledge of some of the principles of machines will help the pupils to understand the tools they may use in any employment.

Drawing.—Careful drawing of the apparatus used helps to fix the experiment in the mind and at the same time gives practice in art.

Composition.—Pupils must have ideas before they can write. The description of the experiment will make a good composition exercise, oral or written.

LIST OF REFERENCE BOOKS AND BULLETINS

GARDEN AND PLANT STUDY

Bulletins of the Ontario Department of Agriculture, Toronto.
Bulletins of the Dominion Department of Agriculture, Ottawa.
Improvement of School Grounds. Department of Education, Toronto.

Atkinson..... First Studies of Plant Life. Ginn & Co. 60 cents.

Bailey..... Manual of Gardening. Macmillan Co. $2.00.

Blanchan..... Nature's Garden. Doubleday Co. $2.00.

Comstock, A. M. ..... Handbook of Nature Study. Comstock Pub. Co. $3.25.

Gray..... Field, Forest, and Garden Botany. Amer. Book Co. $1.40.

Green, Louise..... Among School Gardens. Charities Pub. Co. $1.25.

Hodge..... Nature Study and Life. Ginn & Co. $1.50.

Holt ..... Nature Study. Scribners' Sons. $1.50.

Jackson and Dougherty. Agriculture through the Laboratory and School Garden. Judd. $1.50.

James..... Agriculture. Appleton & Co. 80 cents.

Keeler..... Our Native Trees. Scribners' Sons. $2.00.

Osterhout..... Experiments with Plants. Macmillan Co. $1.50.

Parsons..... How to Plan the Home Grounds. Doubleday Co. $1.00.

Sergeant..... Corn Plants. Houghton, Mifflin Co. 75 cents.

PHYSICAL SCIENCE

Miller..... Minerals and How They Occur. The Copp, Clark Co. $1.50.

Milliken and Gale..... First Course in Physics. Ginn & Co. $2.00.

Newman..... Laboratory Exercises. Ginn & Co. 10c. each.

Remsen..... College Chemistry. Am. Pub. Co. $2.50.
Simmons and Syenhouse Science of Common Life. The Macmillan Company. $1.00.
Woodhull.....Home-made Apparatus.
High School Text-books.

ANIMAL STUDY

Bulletin No. 52. Dominion Department of Agriculture, Ottawa.
Bulletin No. 134. Ontario Department of Agriculture, Toronto.
Bulletin No. 161. Ontario Department of Agriculture, Toronto.
Bulletin No. 124. Ontario Department of Agriculture, Toronto.
Reports of Entomological Society of Ontario. Department of Education.
Fishes of Ontario. Nash. Department of Education.
Bailey and Coleman.... First Course in Biology. The Macmillan Company. $1.25.
Buchanan..... Senior Country Reader. The Macmillan Company. 40 cents.
Chapman.....Bird Life. Appleton. $2.00.
Crawford.....Guide to Nature Study. The Copp, Clark Co. 90 cents.
Dearness.....How to Teach the Nature Study Course. The Copp, Clark Co. 60 cents.
Jordan and Kellogg....Animal Life. Appleton & Co. $1.20.
Kellogg..... Elementary Zoology. Holt & Co. $1.35.
Reed.....Bird Guide—Parts I and II. Musson Book Co., Toronto. 40 cents each.
Shaler.....Domesticated Animals. Scribners' Sons. $2.50.
Silcox and Stevenson..Modern Nature Study. The Macmillan Company. 75 cents.

NOTE.—The bulletins named above are supplied free to schools. Chemical and Physical Apparatus and Entomological Supplies may be obtained from G. M. Hendry Co., Victoria Street, Toronto. Rocks and Minerals may be obtained from the Ward Natural Science establishment, Rochester, or from the Central Scientific Co., Chicago.

PHYSICAL SCIENCE

FORMS III AND IV

DESIRABLE APPARATUS

1 lb. glass tubing in 3 ft. lengths $\frac{3}{16}$ in. to $\frac{1}{4}$ in. outside diameter.	
6 Florence flasks, 4 oz. to 8 oz.	$ .50
1 Funnel, 3 in. diameter	.10
1 Beaker, 8 oz.	.10
1 Evaporating dish	.10
3 ft. pure gum rubber tubing $\frac{1}{8}$ in. inside	.25
$\frac{1}{2}$ sq. foot thin sheet rubber	.20
1 doz. test-tubes 6 in. by $\frac{5}{8}$ in.	.20
$\frac{1}{2}$ doz. test-tubes 6 in. by $\frac{7}{8}$ in.	.10
Capillary glass tubing, 3 sizes	.10
2 rubber stoppers No. 2, one hole	
1 " " " 4, " "	
1 " " " 7, two holes	.30
2 watch glasses	.10
Ball and ring	1.00
2 Dry cells	.60
2 Bar magnets	.50
1 Chemical thermometer 212 deg. F. to O deg. F.	.40
1 Spirit-lamp	.20
1 Retort, 4 oz. stoppered	.15
Wax candles	.10
Retort stand of iron, two rings	.85
1 Thistle tube	.10
Common corks, assorted	.10
Filter paper 5 in. diameter	.05
Test-tube holder	.10
Test-tube rack	.10
Test-tube cleaner	.10
1 piece glass tubing 30 in. long, $\frac{1}{4}$ in. inside, for barometer	.20
1 clamp for closing rubber tube	.10

Covered copper wire	.10
Small compass	.50
Glass model of common pump	1.00
Globe for weighing air	2.50
Small piece of platinum foil, ½ in. by 2 in.	.25
Glass prism 60	.50
Tuning fork 4½ in.	.50
Electric bell	.50
Motor (Ajax)	1.50
Balance	10.00
Air-pump	15.00
Iron wire gauze	.05
Sheet metals, iron, copper, zinc, lead, aluminum	.25
2 lamp chimneys, straight ones preferred, at 10c	.20
Iron ball, 2 in. in diameter	.20
2 dairy thermometers at 15c	.30

CHEMICALS

Sulphuric acid, 1 lb.	.10
Hydrochloric acid, 8 oz.	.10
Nitric acid, 4 oz.	.10
Washing soda	.05
Sugar	.05
Salt	.05
Blue vitriol	.10
Alum	.05
Saltpetre	.05
Sulphur	.05
Potass. permanganate	.05
Lime	.05
Plaster-paris	.05
Potass. bichromate	.10
Methylated spirits, 1 pt.	.10
Alcohol, 95%	.10
Iodine crystals	.10
Mercury, 1 lb.	1.00
Pot. chlorate	.15
Manganese dioxide	.10

Phosphorus	.10
Sweet oil, 2 oz.	.10
Benzine, 2 oz.	.10

The following tools will be found very valuable: saw, square, plane, brace and bit, knife, hammer, glass cutter, files—round, flat, and triangular.

Where the circumstances will not allow of the purchase of the preceding list, the following apparatus is recommended as sufficient for the performance of a large number of the experiments:

½ lb. glass tubing in 3 ft. lengths, $\frac{3}{16}$ in. and ¼ in. outside	$ .20
2 Florence flasks, 4 oz.	.15
1 Funnel	.10
2 ft. pure gum rubber tubing, ⅛ in. inside	.15
½ doz. test-tubes assorted, $\frac{5}{8}$ to $\frac{7}{8}$ diameter, 6 in. long	.20
2 rubber stoppers, No. 2, one hole	.10
1 rubber stopper, No. 4, one hole	.10
Expansion of heat apparatus (made at blacksmith's)	.10
Common corks, assorted	.10
1 chemical thermometer 0 deg. F. to 212 deg. F.	.40
1 spirit-lamp, 4 oz.	.10
1 thistle tube	.10
Covered wire, copper	.10

CHEMICALS

Iodine crystals	.10
Sulphuric acid, 1 lb.	.10
Methylated spirits 1 pt.	.20
Alcohol, 95%	.10
Mercury, ½ lb.	.50
Pot. chlorate	.15
Manganese dioxide	.10

The following may be obtained, for either list, at little or no cost from household stores or home-made sources: washing soda, sugar, salt, ammonia, coal, coke, saltpetre, sulphur, blue vitriol, alum, potass. bichromate, blueing, lime, pickle-jars, wire gauze, candles, wire, sheet metals, test-tube holder and rack, balance, battery cells, horseshoe magnet, pneumatic trough, lamp chimneys, tin cans, melting spoon, bicycle pump, baking-powder.

For home-made apparatus, consult *Laboratory Exercises in Physics* by Newman, Ginn & Co., 50c., and Manual on *Manual Training*.

Reference has been made in the preceding experiments to the use of simple and easily contrived apparatus. The more of this the pupils can contrive and make under the direction of the teacher, the more valuable will be the course in Physical Science.

GRENET CELLS

Into a pint gem-jar put water 10 parts, sulphuric acid 1 part, potass. bichromate 1 part. Have jar three quarters full. Cut a piece of board 4 in. square, bore two holes in it, and through the holes thrust two pieces of electric light carbon, 5 in. or 6 in. long. The outer edges of the carbons should not be more than two inches apart. With a saw, cut a slit in the board between the holes and insert a strip of zinc 2 in. by 7 in. previously rubbed over with mercury. Set the three elements in the jar, connect the two carbons to one wire, and the zinc to another.

One cell of this kind will run a small motor, operate a telegraph sounder, make a simple electro-magnet, or ring an electric bell; two cells will decompose water; three will heat a piece of fine iron wire red-hot.

DECOMPOSITION APPARATUS

1. Cut the neck end from a pickle bottle. Get a No. 1 stopper, (rubber) with two holes in it and insert a piece of platinum foil 2 in. by $\frac{1}{8}$ in. into each hole so that $\frac{1}{2}$ in. projects above and below. Insert a tight plug beside each strip, thus holding it fast and making the stopper water-tight. Insert the stopper into the neck of the jar. Pour into the vessel thus formed enough water to cover the platinums, and add a few drops of sulphuric acid. Touch the wires from the battery to the lower ends of the strips. Note bubbles of gas arise from the platinums. These may be collected in test-tubes and found by test to be oxygen and hydrogen.

2. Fasten a strip of platinum 1 in. by $\frac{1}{8}$ in. to each wire from the battery and dip these into some acidulated water contained in a tumbler. The decomposition of the water into two gases can be seen, but the gases cannot be collected so readily as in 1 above. Bits of electric light carbon will do instead of platinum if the current is not too weak.

PNEUMATIC TROUGH

When oxygen or other gas is to be collected over water, use a milk pan or similarly shaped vessel.

SPIRIT-LAMP

Use an ink-bottle to contain the alcohol and several strands of string for the wick; make a hole in a piece of tin and draw the wick through; then let the tin rest on the neck of the bottle to support the wick.

BAROMETER

A siphon barometer takes less mercury than a cistern barometer. To the open end of the barometer tube attach a piece of strong rubber tubing 4 in. long and to this a piece of glass tubing 3 in. long. Fill the tube thus formed with mercury to within 3 in. from the top. Holding the short glass tube open end up, turn the long tube closed end up. (A tube of $\frac{1}{8}$ in. bore needs only one quarter of the mercury required to fill a tube $\frac{1}{4}$ in. bore.)

HYGROMETER

For a hygrometer, suspend two dairy thermometers side by side against the wall, cover the bulb of one with thin muslin, and let the muslin hang down and dip into water in some small vessel placed about three inches below the bulb on a little shelf.

HINTS

To avoid explosions, a spirit-lamp should be kept filled.

Toy rubber balloons answer well for sheet rubber.

Red ink makes good colouring matter.

Make touch-paper by soaking any porous paper in a solution of saltpetre, and drying it.

Instead of bending glass tubes, join them with rubber tubing.

To make a test-tube holder, fold a sheet of paper until it is about half an inch wide and wrap this around the tube.

To bend glass tubing, hold in the flame of the spirit-lamp and rotate between the fingers till it becomes soft and flexible, remove from the flame, and bend.

To break glass tubing, first scratch with a file.

To break glass bottles, make neatly a deep cut with a file, then touch the glass near the cut with a red-hot wire. When a crack appears, move the hot wire and the crack will follow. Several heatings may be necessary.

In the case of a heavy glass bottle, file the cut as before, wrap the bottle with string dipped in alcohol, light it, and after it has burned, plunge the bottle vertically into cold water.

Melted paraffin is good for closing small leaks.

TIME APPORTIONED TO NATURE STUDY

The Nature Study lesson should be given a definite place on the time-table. It is recommended that each class should have at least one lesson of fifteen minutes in length, a week. In addition to this, about five minutes a week should be spent in assigning problems for out-of-door work and in discussing the observations which the pupils have made on problems previously assigned.

CHAPTER III

FORM I

AUTUMN

GARDEN WORK

On the re-opening of school after the summer holidays, the pupils should see that their plots are put into good order without delay. If they have been neglected during the holidays, a good deal of attention will be needed, and in some cases it may not be possible to reclaim them because of prolonged neglect. If such plots are found, they should be cleaned off completely, spaded up, and left in readiness for planting the following spring. All plots should be cultivated throughout the month of September to keep the soil mellow and prevent the growth of weeds. The pupils should be allowed to pick flowers from their own plots, but should always leave a few in bloom for the sake of the general appearance of the garden. Paths should be kept clean, and all rubbish, weeds, dead plants, etc., removed to the compost heap, which should be in the least conspicuous part of the garden. Hoes, rakes, and claw-hand weeders should be used in cleaning up and cultivating the plots. The soil should be kept fine and loose on top to prevent drying out.

LESSONS ON A GARDEN PLANT

PANSY

LESSON I

Materials.—A flower for each pupil
A plant set into a flower-pot
A leaf for each pupil
A pile of leaves containing a few pansy leaves and several of other kinds.

Introduction.—A conversation with the pupils about their favourite flowers.

Observations.—The pansy flowers are now distributed and the general form of the flower is first noted. The resemblance to the face of an animal will be discovered. The name *corolla* is given, but no other botanical terms are to be introduced in this lesson.

The details of colours, perfumes, velvety feeling of the corolla, and the number of leaflets in it are next *discovered* and described by the *pupils*. Lastly, in a withering flower they discover the seed cases and the little seeds.

LESSON II

The conception of the relationship between the flower, root, and stem is developed by a method similar to the following:

What soon happens to a pansy flower after it is broken from the plant? Are the flowers that you have in your hands withering?

How can you keep them from withering?

Hence, what must the flower get from the stem?

Where does the stem get the moisture?

Hence, what is one use of the root?

A pupil is asked to pull the plant out of the soil in the flower-pot. What is another use that you have discovered for the root?

The plant is now uprooted from the soil, and the pupils examine the root to find how it is fitted for gathering water and food from the soil and for holding the plant in place.

Note the number of branches touching a great deal of soil and also the twisted form of the roots for grasping the soil.

The form of the leaves is studied by the pupils, and, as a test of the accuracy of their observation, they are asked to pick out the pansy leaves from the pile of leaves.

To the teacher.—The pupils must be active participants in the lesson. They must use their eyes, hands, and even their noses in gaining first-hand impressions, and they are to be required to express in their own way the things that they discover. The beautiful flower with its face like that of an animal is an appeal to the child's imagination, and the child's interest in the *use* of things is utilized in the study of the relations of root, stem, and flower.

This lesson may be used as the basis for busy work by means of the following correlations:

1. With art:

   Represent the flower in colours.

2. With reading and literature:

   The pupils are required to express the meaning and sentiment of the following stanza:

   The pansy wakes in early spring
   To make our world more bright;
   All summer long its happy face
   Fills children with delight.

Lessons similar to those on the pansy may be based upon the following plants of the garden or field: dandelion, aster, buttercup, nasturtium, goldenrod. The teacher in preparing the lesson should read a description of the plant from a Nature Study book and should also study the plant itself until he is familiar with all the phases of its life.

OBSERVATION EXERCISES ON THE DANDELION

The exercises given below are suggestive for out of school observation work, but must not be too long. By way of preparation for an exercise of this kind, the interest of the pupils in the dandelion must first be aroused.

FIRST EXERCISE

The teacher places the pupils at the school windows from which dandelions are visible and asks them to name any flower that they can see. A short conversation about the brightness of the flower follows.

The pupils are next instructed to:

1. Find dandelions late in the evening, and find out how they prepare to go to sleep and how they are tucked in for the night.
2. Find where the leaves of the dandelion are, and bring a leaf to school next morning, and also observe how the leaves are grouped or placed.

To the teacher.—Dandelion flowers close up in the evening; the green leaves beneath the head wrap closely around the flowers to form a snug covering. The leaves have margins with teeth shaped like those of a lion, and from this the plant gets its name, for the name is the French *dent de lion,* which is pronounced very much like

the word dandelion. The use of the leaf cluster as a system of rain-spouts for guiding the rain toward the root should be noted.

SECOND EXERCISE

1. Why is the dandelion easy to find?
2. What makes it easy to find even in long grass?
3. What insect friends visit the dandelion?
4. Find out just how these visitors act during their visits, and find whether they carry anything to or away from the flowers.

To the teacher.—The bright yellow colour of the dandelion attracts attention. When it grows in long grass, the flower stalk grows long, so that the flower surmounts its obstructions and climbs up to the sunshine. The flowers are visited by ants, bees, and wasps, and these may be seen burrowing into the flowers in search of honey. If their bodies and legs be touched, the yellow pollen of the flowers will be found sticking to them.

THIRD EXERCISE

1. Look for flower heads that do not open to the sun. Do not disturb them, but watch them for a few days and find out what they become.
2. Examine the large white balls of the dandelions and find out what they are.
3. Blow the down away. What does it carry with it?

To the teacher.—In this exercise the pupils will learn that the large white balls are the mature, or ripened, flowers and are composed of little brown seeds, each being a little airship for wafting it away.

CORRELATION WITH LITERATURE AND READING

When the above exercises have been completed, the pupil's knowledge of the dandelion may be utilized in interpreting the following stanzas:

Oh dandelion! yellow as gold,
What do you do all day?
I just wait here in the tall green grass
Till the children come to play.

And what do you do when your hair is white
And the children come to play?
They take me up in their dimpled hands
And blow my hair away.

In addition to the dandelion, the following plants are suitable for observation exercises: morning-glory, wild balsam, sweet-pea, snap-dragon, nasturtium.

DWARF NASTURTIUM

Observations.—The size of the plant at the time of flowering; its leaves—size, colour, shape, length of petiole and how arranged; colours found in the flower, comparison with others of same species found in the garden; size and shape of the flower and the length of its stems. Do the flowers grow higher than the leaves? Do they look better when with the leaves or when alone? Note the perfume and taste of the flower stem, the insect visitors, and what part of the flower they tried to get at, when the first blossom was seen, and how long the blossoms continued to come out. Do they keep well in bouquets? Do they stand hot, dry weather as well as other flowers? When did the frost kill them? Compare with the climbing nasturtium. Find the seeds.

SEEDS

The autumn months are the best for seed studies, for almost all annuals are ripening their seeds at this time of year.

FIELD EXERCISE

Assign to the pupils the following exercise:

Collect the seed pods from as many plants of your garden plots, or home gardens, or wild plants, as possible, and be careful to write the name of each plant on the paper in which you put the seed pod of that plant. Notice the part of the plant from which the seed pod is formed.

CLASS-ROOM LESSON BASED ON THIS COLLECTION

The pupils place the seed pods on their desks, and observations and problems are dealt with of which the following are representative:

How does each seed case open?

What are the seeds for?

How many seeds are in each case?

Why should a plant have so many seeds?

How are the seed cases fitted for protecting the seeds?

Are any two seeds alike in shape?

Are the seeds easy to find if they are spilled upon the ground?

What makes them hard to find?

Where do nearly all seeds spend the winter?

Of what use is the hard shell of the seed?

SEED DISPERSAL

Study only a few of the more striking examples of seed dispersal with the Form I class. Seeds that fly and seeds that steal rides are good examples of classes of seeds whose methods of dispersal will prove of interest to children.

LESSON ON SEEDS THAT FLY

Materials.—A milkweed pod; a ripe dandelion head.

Introduction.—A short conversation about the effects of the crowding of plants, as carrots and turnips, in a garden plot, and hence the need for the scattering of seeds.

Observations. —Open a milkweed pod in the presence of the class, so that they may see how the pod opens, how beautifully the seeds are arranged, and how the silk tufts are so closely packed in together.

Allow a pupil to lift a seed out, blow it in the air, and observe how the silk opens out like an umbrella. Distribute seeds, one to each pupil. Ask the pupils to find out why this little airship is able to carry the seed. They will find that the seeds though broad, are thin and light, and the silky plumes very light.

Ask the pupils to release their milkweed seeds at recess, when out of school, and find out how far they can fly. This is an interesting experiment for a windy day.

The white balls of the dandelion are next examined, the tiny seeds are found standing on tiptoe on a raised platform, each grasping a tiny parachute and waiting for a puff of wind to start them off. A pupil is permitted to give the puff. Seeds are distributed, and the means of flight is compared with that of the milkweed. The shape of the seeds is observed and also the tiny anchor points at

the lower end of the seed for clutching the ground when the seed alights.

Another lesson on seeds that fly can be based on the study of tree seeds, using those of the maple, elm, basswood, pine, and spruce.

CORRELATIONS

1. Drawing of milkweed pods and seeds, and drawing of the dandelion seed-ball and the seeds when floating in the air.

2. Reading and literature. Interpret the thought and read expressively:

Dainty milkweed babies, wrapped in cradles green,
Rocked by Mother Nature, fed by hands unseen,
Brown coats have the darlings, slips of milky white,
And wings, but that's a secret, they're folded out of sight.

TWIGS AND BUDS

The study of buds is a part of tree study and may be taken as observation work in the class-room. This somewhat detailed study should follow the general lessons on tree study.

The materials for the lessons may be collected by the pupils at the time of the field lesson and kept fresh in a jar of water until required for use.

LESSON ON TWIGS

Materials.—A twig of horse-chestnut about six inches long, for each pupil.

A twig of the same tree with the leaves still on it.

Observations.—The twigs are distributed and the teacher asks the pupils to examine them and to describe all marks and projections that can be found on the twig.

Answers are required from the pupils separately. The pupil's answer in each case should be sufficiently clear for all the class to recognize the feature that the answer is intended to describe. A few brief questions will guide the answerer in making his description more definite, but the description should be the result of the pupil's observation and expressed in his own words.

The meaning or use of each feature should be discussed, when possible, immediately after it has been described.

The following features will be discovered and the problems suggested will be solved:

The brown or greenish-brown bark.

The buds.

One bud (sometimes two) is at the end of the twig.

Some buds are along the side of the twig.

What caused the end bud to grow larger than the others?

There is a leaf scar under each bud.

Of what use is it to the bud to be between the twig and the leaf stalk?

The bands of rings, one or more on each twig.

The tiny oval pores, each surrounded by a little raised band.

The detailed study of the buds is left for a separate lesson.

FURTHER STUDY OF TWIGS

The study in detail of various features is illustrated in the following:

Look closely at the leaf scars and describe them fully, as to shape, colour, and marks.

Do the scars look like fresh wounds, or are they healed over? Of what use to the tree is the healing of the scar?

We will learn later that the part of the twig between each pair of bands of rings represents one year's growth. How old is your twig? Who has the oldest twig?

Do all twigs grow at the same rate?

Who has the twig that had the most rapid growth?

To the teacher.—The bud at the end of the twig or its branches is called the end bud; there are two leaf scars underneath it. The buds along the sides of the stem are called side buds, the latter are smaller than the end bud. The bud situated between the stem of the leaf and the twig is in a sheltered position. This position also puts the bud close to the pantry door, for the plant food is prepared in the leaf. The leaf scars are yellowish-brown, or if they are the scars from the leaves of former years, are dark brown in colour. Each scar is shaped like a horse-shoe and tiny dots are found in the position that the horse-shoe nails would have. Even before the leaf falls, a layer of corklike substance has formed over the scar. This layer is a protection against the entrance of frost and rain and germs of fungi and it also prevents the loss of sap from the scar. The tiny oval pores, each as large as the point of a needle, are the breathing pores of the twig. The bands of rings are the scars of the scales of the end buds of successive years. This latter fact can be discovered when the bud is opening.

REVIEW LESSON

The review lesson should consist of a review of the points taken up in the lessons that were based on the horse-chestnut twig, supplemented by the examination of the twigs of elm, apple, or lilac.

LESSON ON BUDS

Materials. — Twigs and buds of horse-chestnut, one for each pupil. An opening bud. (A bud or a twig placed in water in a warm room will develop rapidly.)

Lesson.—Distribute specimens, and review the positions of the buds.

Pupils examine the buds and tell all they can about them. They describe the colour, shape, and size of the buds, and also their gummy and scalelike covering.

Of what use are the gum and scales? Of what use is the brown colour of the bud?

They next find out what is inside the little brown house. They open the buds and try to identify the contents. There will be some uncertainty as to the meaning of the contents. Leave this over till spring.

To the teacher.—The brown colour of the bud makes it an absorbent of sunlight, and also serves as a protection from observation by the sharp eyes of bud-eating birds. The gummy scales are waterproof, and the scales, by spreading open gradually, cause the waterproof property to be retained even after the bud has grown quite large. The inner part of the bud is composed of two, four, or six tiny leaves folded up and supported on a short bit of stem. Some of the buds have, in addition to leaves, a tiny young flower cluster. All of these things are densely covered with white down. The down is the fur coat to protect the tender parts from the cold.

REVIEW LESSON

Review the lesson on buds, but substitute buds of the lilac or apple for the horse-chestnut buds of the original lesson.

CORRELATIONS

The observational study of the buds and twigs is a good preparation for busy work in art and manual training, and the pupils may be assigned exercises, such as charcoal drawing of a horse-chestnut twig, paper cutting of a lilac twig and buds, clay or plasticine modelling of twigs and buds.

For oral and written language exercises, enlarge the vocabulary of the pupils by requiring sentences containing the words—scales, twigs, buds, protection, terminal, lateral, leaf stalk, blade, etc.

LEAVES

Leaves, because of their abundance and the ease with which they may be obtained, are valuable for Nature Study work. It is possible to arouse the interest of even young children in the study of leaves, but care must be taken not to make the observation work too minute and the descriptions too technical for the primary classes.

FIELD EXERCISES

An excursion to the school grounds or to some neighbouring park will suffice to bring the pupils into direct contact with the following plants: a maple tree, a Boston ivy (or other climbing vine), a nasturtium, a geranium.

Ask the pupils to find out where and how leaves are placed on each of these plants, that is, whether they are on the inner parts of the branches of the tree or out at the ends of the branches. Do the leaves overlap one another or does each make room for its neighbours? Are the leaves spread out flat or curled up? What holds the leaves out straight and flat? What do the leaves need to make them green and healthy?

Are the leaves placed in the right way, and are they of the right form to get these things?

To the teacher.—The leaves of the plants named are quite noticeably so placed on the plants, have such relations to one another, and are of such outline that they present the greatest possible surface to the *air* and *sunshine* and *rain*. The leaf stalk and midrib and veins are stiff and strong to keep the leaves spread out. Compare with the ribs of an umbrella. The benefit of sunshine to leaves and plants can be developed by discussing with the pupils the paleness and delicateness of plants that have been kept in a dark place, such as in a dark cellar. They are also acquainted with the refreshing effect of rains upon leaves. The use of air to the leaves is not so easy to develop with pupils of this age, but the use of air for breathing just as boys and girls need air for breathing may be told them.

CLASS-ROOM LESSON ON LEAVES

Introduction.—Tell me all the things that you know upon which leaves grow. On trees, bushes, flowers, plants, vegetables, etc.

Are leaves all of the same shape?

To-day we are going to learn the names of some of the shapes of leaves.

Observations. —Show the class the heart-shaped leaf of catalpa or lilac, and obtain from the pupils the name *heart-shape*. Use the following types:

Maple leaf as star-shape,
Grass or wheat or corn as ribbon-shape,
Nasturtium or water-lily as shield-shape,
Ash or rowan, as feather-shape.

Drill.—Pupils pick out the shape named.
Pupils name the plant to which each belongs.
Which shape do you think is the prettiest?

GARDEN STUDIES

If the pupils of this Form have planted and cared for garden plots of their own, they will have a greater love for the flowers or vegetables that grow in them than for any others in the garden, because they have watched their development throughout. For them such continuous observation cannot but result in a quickening of perception and a deepening of interest and appreciation.

STUDIES IN THE PUPIL'S INDIVIDUAL PLOT

What plant is the first to appear above ground? What plant is the last to appear? Describe what each plant was like when it first appeared above ground. What plants grow the fastest? What effect has cold weather, warm weather, dry weather, on the growth of the plants?

What weeds grow in the plot?

Why do these weeds obstruct the growth of the other plants?

What kind of root has each weed?

Find out what kind of seeds each weed produces?

Why is each weed hard to keep out of fields?

What garden plants produce flowers?

How are the seeds protected?

Compare the seeds with those that you planted.

Select the seeds of the largest plants and finest flowers for next year's seeding.

STUDIES FROM THE GARDEN AS A WHOLE

What plants grow tallest?

What plants are most suitable for borders?

What plants are valuable for their flowers?

What plants are valuable for their edible roots, for their edible leaves, for their edible seeds?

How are the edible parts stored for winter use?

Compare the plants that are crowded, with others of the same kind that are not crowded.

Compare the rate of growth of the plants in a plot that is kept hoed and raked with the rate of growth of plants in a neglected plot.

BULB PLANTING

The planting of bulbs in pots for winter blooming should be commenced with pupils in Form I and continued in the higher Forms. As a rule, the potted bulbs will be stored and cared for in the home, as most school-rooms are not heated continuously during the winter. Paper-white narcissus and freesia are most suitable and should be planted about the fifteenth of October, so that the plants will be in bloom for Christmas.

LESSON ON BULBS AND BULB PLANTING

Materials.—The bulbs to be planted.

As many four-inch flower-pots or tomato cans as are required.

Soil, composed of garden loam, sand, and well-rotted manure in equal proportions. Stones for drainage.

Sticks for labels (smooth pieces of shingle, one and a half inches wide and sharpened at one end, will answer).

Pictures of the plants in bloom.

Observations.—The attention of the pupils is directed to the bulbs, and they are asked to describe the size, form, and colour of each kind of bulb.

A bulb is cut across to make possible the study of the parts, and the pupils observe the scales or rings which are the bases of the leaves of the plant from which the bulb grew. The use of the fleshy mass of the bulb as a store of food for the plant that will grow from it is discussed.

The sprout in the centre of the scales with its yellowish-green tip is observed, and its meaning inferred.

The picture is shown to illustrate the possibilities within the bulb.

PLANTING THE BULB

The teacher directs, but the work is done by the pupils, and the reasons for the following operations are developed:

What is the use of the one-inch layer of pebbles, or broken brick, or stone, that is placed in the bottom of the pot?

Why are the bulbs planted near the top of the soil?

Why is the soil packed firmly around the bulbs?

Why must the soil be well wetted?

Why is the pot set in a cool, dark place for a month or more?

To the teacher.—The pebbles or broken bricks are for giving drainage. The bulbs are planted with their tips just showing above the surface of the soil and there is about half an inch of space between the top of the soil and the upper edge of the pot in order to facilitate watering.

The potted bulbs must be set in a cool, dark place until they are well rooted. This is subjecting them to their natural winter conditions, and it will cause them to yield larger flowers, a great number of flowers, and flowers that are more lasting. Sand in the soil permits of the more free passing of air through the soil. Basements and cellars are usually suited for storing bulbs until they have rooted, but they must not be warm enough to promote rapid growth. The pots when stored should be covered with leaves, sawdust, or coarse sand to prevent drying out. The soil must be kept moist, but not wet. Paper-white narcissus, if brought out of the dark after three or four weeks, will be in bloom at the end of another month if kept in the window of a warm room. Care must be taken not to expose the plants to bright light until they have become green. The bulbs of the white narcissus are to be thrown away after the flowers have withered, as they will not bloom again, but freesia bulbs may be kept and planted again the following year.

CHAPTER IV

FORM I

WINTER

LESSONS ON A PET ANIMAL: THE RABBIT

I

THE lesson is introduced by a conversation with the pupils about their various pets.

Since we are to have a rabbit brought to the school we must learn how to take care of it, and the proper method of taking care of it is based upon a knowledge of the habits of the wild rabbit.

Where do wild rabbits live?

What sort of home does a rabbit have?

In what ways does this home protect the rabbit?

Hence, what kind of home must we have ready for the rabbit?

What does the rabbit eat?

Are there any of these foods that are not good for its health?

Give a list of foods that you can bring for the rabbit. Why will the rabbit, when kept in a hutch, require less food than one that runs about?

Since the rabbit likes a soft bed, what can you bring for its bed?

II

Observations.—The teacher or a pupil brings a rabbit to the school-room, where, during recreation periods, the

pupils make observations on topics suggested by the teacher, such as:

Its choice of food; its timidity; its movements—hopping, squatting, listening, scratching, and gnawing.

These observations are discussed in the class and are corrected or verified.

To the teacher.—Wild rabbits live in the woods or in shrubbery at the edges of fields. The home of the rabbit is either a burrow under ground or a sheltered place under a root or log closely concealed among the bushes. This home is dry and affords a shelter from enemies, and from wind, rain, and snow. From this we know that we must provide a dry bed for our rabbit in a strong box in which it will feel secure, and in which it will be protected from wind and rain. The food of the rabbit consists of vegetables and soft young clover and grains. It also gnaws the bark of trees, and in winter it feeds upon buds. We can, therefore, feed our rabbit on carrots, beets, apples, oats, bran, grass, and leaves of plants, and we must provide it with some twigs to gnaw, for gnawing helps to keep its large chisel-shaped teeth in good condition. We must be careful not to give it too much exercise, and we must not give it any cabbage, because this is not good for the rabbit's health. A dish of water must be placed in the hutch, for the rabbit needs water to drink.

III

Details, if studied in isolation, are uninteresting to Form I pupils. Detailed study should be based upon the animal's habits, movements, and instincts, and each detail should be studied as an answer to questions such as: How is the animal able to perform these movements? How is the animal fitted for this habit of life, etc.?

Watch the rabbit moving. How does a rabbit move? Which legs are the more useful for hopping? How are the hind legs fitted for making long hops?

Why is the rabbit able to defend itself by kicking with its hind feet? Find out how the rabbit is fitted for burrowing.

Listen carefully and find out whether the rabbit makes much noise while moving. Of what advantage is it to the rabbit to move silently?

Find out, by examining the feet of the rabbit, what causes it to make very little noise.

How are rabbits prepared for living during cold weather?

Test the ability of the rabbit to hear faint noises. Why is it necessary for the rabbit to be able to hear faint sounds? How is it fitted for hearing faint sounds?

Examine the teeth and find out how they are fitted for gnawing.

To the teacher.—The long, strong, hind legs of the rabbit are bent in the form of levers and enable the animal to take long, quick hops.

When the rabbit attacks, it frequently defends itself by vigorous kicks with its hind feet, which are armed with long, strong claws. Ernest Thompson-Seton's story of Molly Cottontail and "Raggylug", in *Wild Animals I Have Known,* contains an interesting account of how Molly rescued Raggy from a snake by this manner of fighting. The rabbit has many enemies, hence it has need of large, movable ears to aid its acute sense of hearing. The thick pads of hair on the soles of its feet enable it to move noiselessly. The thick, soft, inner hair keeps the animal warm, while the longer, stiffer, outer hair sheds the rain.

Impress upon the pupils the cruelty of rough handling of the rabbit and of neglecting to provide it with a place for exercise and with a clean, dry home.

The following pet animals may be studied, using the same order and general method of treatment: pigeon, cat, canary, guinea pig, white mouse, racoon, squirrel, parrot.

In many cases these animals can be brought to school by the pupils. Encourage the keeping of pet animals by the pupils, for the best lessons grow out of the actual care of the pets. The study of a pet bird may be conducted along lines similar to the outline given below for the study of the pigeon.

CORRELATIONS

With literature and reading: Ernest Thompson-Seton's "Raggylug".

With art: Charcoal drawing representing the rabbit in various attitudes, as squatting, listening, hopping.

With modelling in clay or plasticine.

With paper cutting.

With language: The vocabulary of the pupils is enlarged by the introduction of new words whose meaning is made clear by means of the concrete illustration furnished by direct observation of the rabbit.

They use these new words in sentences which they form in describing the rabbit; for example: hutch, gnaw, padded, cleft lip, timid.

The rabbit has padded feet so that it can walk without noise. The rabbit has a soft bed in its hutch.

THE DOMESTIC CAT

The following facts are suggested as topics for a first lesson on the domestic cat. The teacher can rely upon the

pupil's knowledge of the cat to furnish these statements of fact during a conversation lesson:

The cat goes about at night as readily as during the day.

The cat can hear faint noises quite readily.

The cat can walk noiselessly.

The cat creeps along until it is close to its prey, then pounces upon it, and seizes it with its claws.

The cat enjoys attention and purrs if it is stroked gently.

The cat likes to sleep in a warm place.

The cat can fight viciously with her claws.

The cat keeps her fur smooth and clean and her whiskers well brushed with her paws.

The cat eats birds, mice, rats, meat, fish, milk, bread, and cake.

DETAILED STUDY

Base the study of the details upon the facts of habit, movements, instincts, etc., which were developed in the preceding lesson.

Observations.—Find out how the cat's feet are fitted for giving a noiseless tread.

Find the claws.

How are the claws fitted for seizing prey?

How are the claws protected from being made dull by striking against objects when the cat is walking?

THE PIGEON

A pigeon is kept in a cage in the school-room and the pupils observe: its size as compared with that of other birds; outline of body, including shape of head; the feathers, noting quill feathers, and covering or contour feathers; manner of feeding and drinking; movements, as walking, flying, tumbling.

The owner or the teacher describes the dove-cot, the necessity of keeping it clean, the use of tobacco stems for killing vermin in the nest, the two white eggs, the habits of male and female in taking turns in hatching, the parents' habit of half digesting the food in their own crops and then pouring it into the crops of the young, the rapid growth of the young, the next pair of young hatched before the first pair is full-fledged.

Descriptions of the habits of one or more well-known varieties—pouters, fantails, homing pigeons, etc. Read stories of the training and flights of homing pigeons, from Ernest Thompson-Seton's *Arnex*.

MORE DETAILED STUDY FOR CLASS WORK

Compare the uses of the quill and contour feathers. Find out how these two kinds differ in texture; the differences fitting them for their difference in function. The names quill and contour may be replaced by some simple names, as feathers for flying and feathers for covering the body.

Study the adaptations for flight, noting the smooth body surface, the overlapping feathers of the wing for lifting the bird upward as the wing comes down, the long wing bones, the strong breast, and the covering of feathers giving lightness and warmth. The warmth and lightness of feathers is illustrated by the feather boas worn by ladies.

Examine the feet and find out why pigeons are able to perch on trees.

Examine the beak, mouth, tongue, nostrils, eyes, ears. How is the bill adapted for picking up grains and seeds?

OBSERVATION AND CARE OF WINTER-BLOOMING PLANTS

Children are most interested in things which they own and care for themselves. If a child plants a bulb or a slip and succeeds in bringing it to maturity, it will be to him the most interesting and, at the same time, will bring him more into sympathy with plants wherever he may find them. The teacher should impress upon the pupil the desirability of having beautiful flowers in the home in winter, when there are none to be had out-of-doors.

Every pupil should be encouraged to have one plant at least, and the bulbs planted in October and stored away in the dark in the home cellar will require a good deal of care and afford an excellent opportunity for observing plant growth and the development of flowers. If the pots have been stored in a cool cellar and have been kept slightly moist, the bulbs will have made sufficient root growth in a month and should be brought up into a warmer room where they can get some sunshine every day. The pupils will make a report each week as to what changes are noticeable in the growing plant. They will note the appearance of pale green shoots, which later develop into leaves and at least one flower stalk. They should make a drawing once every week and show it to the teacher, and the teacher should make it a point to see a number of the pupils' plants by calling at their homes. In this way the pupils come to know what plants need for their development in the way of soil, water, light, and heat. This interest will soon be extended, until, in a very few years, the children will add new and beautiful plants to the home collection and assume the responsibility of caring for all of them.

TREES

PINES OF THE LOCALITY

This study may be commenced in November after the deciduous trees have lost their leaves and have entered their quiescent winter period. This is the time when the evergreens stand out so prominently on the landscape in such sharp contrast with the others that have been stripped of their broad leaves and now look bare and lifeless. If no pines are to be found in the vicinity, balsam or spruce may be substituted. The lessons should, as far as possible, be observational. The pupils should be encouraged to make some observations for themselves out of school. At least one lesson should be conducted out-of-doors, a suitable pine tree having been selected beforehand for the purpose. The following method might serve as a guide in the study of any species of tree.

THE WHITE PINE

FIELD EXERCISES

Have the pupils observe the shape and height of the tree from a distance, tracing the outline with the finger. Compare the shape of this tree with that of other evergreens and also with that of the broad-leafed trees. Have them describe in what particulars the shapes differ in different trees. They will come to realize that the difference in shape results from difference in length, direction, and arrangement of branches. They may notice that other evergreen trees resemble the pine in that the stems are all straight and extend as a gradually tapering shaft from the bottom to the top, that all have a more or less conical shape, and that the branches grow more or less straight out from

the main stem, not slanting off as in the case of the maples and elms.

Coming close to the tree, the pupils may first examine the trunk. By using a string or tape-line, find its diameter and how big it is around. Tell them how big some evergreens are (the giant trees of the Pacific Coast are sometimes over forty feet around). Have them notice where the trunk is largest, and let them find out why a tree needs to be so strong at the ground. Heavy wind puts a great strain on it just at this point. Illustrate by taking a long slat or lath, drive it into the ground firmly, and then, catching it by the top, push it over. It will break off just at the ground. If a little pine tree could be taken up, the pupils would be interested in seeing what long, strong, fibrous roots the pine has.

Let them examine the bark of the trunk and describe its colour and roughness. The fissures in the bark, which are caused by the enlarging of the tree by the formation of new wood under the bark, are deeper at the bottom of the tree than at the top, the tree being younger and the bark thinner the nearer to the top we go.

Let the pupils look up into the tree from beneath and then go a little distance away and look at it. They will notice how bare the branches are on the inside, and the teacher will probably have to explain why this is so. They will discover that the leaves are nearly all out toward the ends of the branches as they get light there, while the centre of the tree top is shaded, and the great question that every tree must try to solve is how to get most light for its leaves. The pupils will now see an additional reason why the lower limbs should be longer than the upper ones. The greater length of the lower limbs brings the leaves out into the sunlight.

The reason for calling this tree an "evergreen" may now be considered. Why it retains its leaves all winter is a problem for more advanced classes; but if the question is asked, the teacher may get over the difficulty by explaining to the class that the leaves are so small, and yet so hardy, that wind, frost, or snow does not injure them. Each pupil may bring a small branch or twig back to the school-room for use in a class-room lesson.

CLASS-ROOM LESSON

Materials.— Small branches—one for each pupil, cones, bark, pieces of pine board.

Introduction.—Review the general features of the pine that were observed in the field lesson.

Observations. — The branches are distributed. Pupils test the strength and suppleness of the branches and find the gummy nature of the surface.

Of what value are these qualities to the tree during winter storms?

Examine the texture, stiffness, and fineness of the needles.

Note that the needles are in little bunches. How many are in each bunch?

Are there any buds on the branches?

If so, where are the buds?

How are the buds protected from rain?

The pupils examine the cones and describe their general shape.

The pupils are asked to break open the tough scales and find the seeds.

Allow the seeds to fall through the air, and thus the pupils will discover the use of the wings attached to the seeds.

The wood is next examined, its colour and odour are noted, and its hardness is tested.

Find articles in the school-room that are made of pine wood.

ELM

The following topics are suggested for aiding in the selection of matter for a lesson on a typical broad-leafed tree:

The height of the tree.

The part of the height that is composed of tree tops.

The umbrella shape or dome shape of the top.

The gracefully drooping branches of the outer part of the top.

Try to find other trees with tops like that of the elm.

The diameter of the trunk.

The diameter is almost uniform up to the branches.

The branches all come off from one point, like the ribs of an umbrella.

The thick bark, that of the old trees being marked by deep furrows.

The birds that make their nests in the elm.

In spring find and examine the flowers, fruits, seeds, and also the leaves.

FIELD EXERCISE

A good out-of-door exercise to follow the general lesson outlined above, is to require the pupils to find all the elm trees or a number of elm trees growing in the locality and to describe their location and the kind of soil on which they grow.

The maple, oak, horse-chestnut, and apple are also suitable trees upon which to base lessons for Form I.

DOMESTIC ANIMALS

Domestic animals not only furnish suitable subjects for observation work, but also afford good opportunities for developing that sympathetic interest in animal life which will cause the pupils to more nearly appreciate the useful animals and to treat them more humanely.

THE HORSE

I

Introduction.—By means of a conversation with the pupils, find out what they know about the horse and lead them to think about his proper treatment.

Lesson.—The matter and method are suggested by the following:

What are the different things for which horses are useful?

What kinds of horses are most useful for hauling heavy loads?

Why are they most useful?

What kinds are the most useful for general farm work? Why are they the most useful?

What kinds are the most useful for driving?

Are there any other animals that would be as useful as the horse for all these things?

What causes some horses to be lean and weary while others are fat and brisk?

What kinds of stables should horses have as to warmth, dryness, and fresh air?

Why is it cruel to put a frosty bit into a horse's mouth?

When a horse is warm from driving on a cold day, how should he be protected if hitched out-of-doors?

Why, when he is warm from driving, should the blanket not be put on until he has been in the stable for a little while?

Correlate with reading from *Black Beauty*.

II

Preparation.—I want you to find out some more things about the horse, but you will understand these things better if you remember that long ago all horses were wild, just as some horses are wild on the prairies to-day, and that the habits learned by wild horses remain in our tame horses.

The teacher should read to the class parts of "The Pacing Mustang" from Ernest Thompson-Seton's *Wild Animals I Have Known*, or "Kaweah's Run" from *Neighbours with Claws and Hoofs*. This will give the pupils a motive for making the required observations.

Observations.—Compare the length of the legs of the horse with his height.

Of what use were these long legs to the wild horses?

What causes horses to "shy"? Of what use was this habit to wild horses?

In how many directions can a horse move his ears? Of what use was this to wild horses?

When horses in a field are alarmed, do they rush together or keep apart, and where are the young foals found at this time? Of what use were these habits to wild horses? Are the eyes of the horse so placed that he can see behind him and to either side as well as in front? Of what use was this to wild horses?

To the teacher.—The horse is an animal which is strong, swift, graceful, gentle, obedient, docile. The pupils should

learn that, in return for his good services, the horse should be treated with kindness and consideration.

The legs of the horse are long, straight, and strong, and the single toe (or hoof) means that the horse walks on the tip of one toe, and the hoof is in reality a large toe nail developed to protect the tip of the toe. To these features is due the great speed of the horse. Horses gather together in the field with the foals in the most protected part of the group, just as wild horses found it necessary to do for protection. The wild horses "shied" at a fierce enemy concealed in the grass, and the tame horse shies at a strange object.

CORRELATIONS

With literature and reading: By interpretation of *The Bell of Atri.*

With language: By exercise on new words, as graceful, etc.

DOMESTIC BIRDS

THE DUCK

Home Observations.—Compare the duck and the drake as to size, colouring, calls, and other sounds.

Observe the position of the birds when standing. Observe their mode of walking, of swimming, and of flying. Where do they prefer to make their nests? Why is the duck more plain in dress than the drake? What is the shape, size, and build of the nest? Describe the eggs. When does the duck sleep? Why can it not sleep upon a perch as hens do? How do ducks feed on land? Compare with the feeding of hens. Observe how ducks feed when in water. Observe the various sounds, as alarm notes, call notes, social sounds.

Describe the preening of the feathers and explain the meaning of it.

Compare the appearance of the young ducks with that of the older ones. Do the young ducks need to be taught to swim?

CLASS-ROOM LESSON

Provide, where convenient, a duck for class study.

Observations.—Colour, size, general shape of the body, and the relation of the shape to ease of swimming; divisions of the body.

Size of head, length of neck, and the relation of the length of the neck to the habit of feeding in water.

The legs and web feet, and the relation of these to the bird's awkward walking and ease in swimming.

The bill and its relation to the bird's habits of feeding by scooping things from the bottom of the water and then straining the water out. The sensitive tip of the bill by which the duck can feel the food.

The feathers, their warmth, and compactness for shedding water. The oil spread over them during the preening is useful as a protection against water.

The bill, feet, and feathers should be compared with those of the hen and goose, and reasons for the similarities and differences should be discussed.

The uses that people make of ducks and their feathers and eggs; the gathering of eider-down.

For desk work, make drawings of the duck when swimming, flying, and standing.

CHAPTER V

FORM I

SPRING

GARDEN WORK

THE pupils in Form I cannot be expected to do heavy work, such as spading plots or making paths. In some cases the larger boys will undertake to line out the walks and do the spading or digging. Sometimes it may be best to engage a man to do the spading. In any case the boys and girls should do the measuring and marking out of the plots. If stable manure is used in fertilizing the plots, it must be well rotted and then carefully spaded into the plots. The rest of the work should be done by the pupils themselves under the direction of the teacher. This work will include the levelling of the plots with hoes and rakes, and the trimming of the edges to the exact size of the plots, as determined by a string drawn taut about the four corner pickets. If the pupils in this Form have individual plots, each pupil will mark out his drills, put in the seeds, and cover them. The teacher may give demonstrations in connection with the work but should not do the work for the pupils.

The teacher must use his own judgment as to what seeds to allow the pupils to plant. One variety of vegetable and one of flowers is sufficient for Form I pupils, and it is desirable that large seeds be chosen for them and such as are pretty sure to grow under ordinary circumstances. Beans, beets, radishes, or lettuces are suitable as vegetables.

and nasturtiums, balsams, or four-o'clocks as flowers. These seeds should be planted at least an inch apart in the drill and the drills, twelve to fifteen inches apart. Large seeds may have an inch of soil over them and smaller seeds much less. Unless the soil is very dry, watering should not be allowed, and in any case it is better to water the plot thoroughly the day before planting the seed instead of after, as is commonly done. The pupils must not allow a crust to form over the plot either before the seeds come up or after. Claw-hand weeders are convenient for loosening the soil close to the plants, and small-sized garden rakes can be used between the rows as soon as the seedlings appear. It is always better to cultivate before the weeds get a start, and thus prevent their growth. Usually the young plants will be too thick in the row, so that thinning should be begun when the plants are about two inches high. The edges of the plots should be kept straight and the paths clean and level. Each plot should have a wooden label bearing the owner's name or number and Form. The teacher is referred to *Circular 13* of the Ontario Department of Education, *Elementary Agriculture and Horticulture,* for lists of seeds, tools, etc.

GARDEN STUDIES

The pupils should be in the garden every day as soon as gardening commences. In this way only will they be able to follow and appreciate the whole life of the plant from seed to seed again. The teacher should give a few minutes daily to receiving verbal reports from the pupils. All new developments that the pupils notice should be reported for the good of all. The teacher should make a practice of visiting the garden for a few minutes daily before or after school, in order that he may be in a position

to direct the pupils in their studies in the garden. The pupils should watch for the first appearance of the young plants above ground, noting how they get through the soil, and the size, shape, and colour of the first leaves. They can readily determine whether all of the seeds grow. They will then watch for the opening of the second pair of leaves and compare them with the first pair. They should report the amount of growth made from day to day, and also what insect enemies attack the plants, and what animals, such as toads and birds, are seen during the season. They will also have occasion to note the effect of rain and sun upon the soil and upon the plants. The first vegetables fit for use and the first flowers in bloom will be reported. While they give special attention to the development of the plants in their own plots, they will of course observe what is going on in the garden generally.

Correlate with the interpretation of "The Seed" in *Nature in Verse*.—Lovejoy. Silver, Burdett & Co., 60 cents.

WINDOW GARDEN

The pupils should plant some seeds in sand or moist sawdust in boxes or pots in the school-room, so that they may be able to examine the progress of germination. In this way they will come to realize that every good seed has in it a tiny plant asleep and that warmth and moisture are needed to awaken it and help it to grow. It sends one delicate shoot down into the soil and another up into the light. Another interesting way to plant seeds is in egg-shells filled with fine, moist soil, which are set in rows in a box of sand. One seed only should be put in a shell. The plants may be grown to quite a size and then set out in the garden plot, the shell having first been broken off and the

ball of earth containing the roots carefully set down in a small hole, packed about with garden soil, and watered. The pupils should draw diagrams or maps of their plots and afterwards of the whole garden. (See Manual on *Geography.*) They can mark the lines of plants, and those who can write can give in short, simple sentences the main things noticed from day to day. They should give the day and date when the seeds were planted, when plants came up, when rain storms occurred, when work in weeding, thinning, and cultivating was done, when the plants were fit to use, and how they were disposed of, etc. This will serve as profitable seat work in writing, drawing, and language. Simple problems based upon dimensions of plots and the value of vegetables, etc., afford excellent supplementary exercises in arithmetic.

WILD FLOWERS

The admiration that even little children have for the wild flowers of the woods and their delight in finding and gathering them is sufficient justification for including them in studies for Form I. The teacher must be careful, however, lest he go too far in the critical examination of the parts of the flowers, forgetting that little children are not interested in stamens and petals, but in the fresh, fragrant, and delicate blossoms that beautify the little banks and hollows of every woodland and that brighten up the fields and roadsides in spring time. The teacher should aim to deepen that childish admiration and give to the child a more intelligent appreciation of the beauties of the wild flowers and a desire to protect them from extermination.

No attempt should be made to prohibit the picking of wild flowers, but the pupils should be instructed not to pull up plants by the roots. The picking of flowers in modera-

tion does not injure the plants, but rather tends to increase their vigour. Pupils should pick flowers with some purpose in view, rather than to see how big a bunch each can gather. The teacher should show them how to arrange a few flowers in a neat bouquet and emphasize the fact that a great mass of blossoms crushed closely together is far from being artistic or ornamental. Pupils should then be encouraged to make up pretty bouquets for the teacher's desk, for the home dining-room, and for old or invalid people who love flowers—especially those plucked by the hands of thoughtful children.

RECOGNITION OF WILD FLOWERS

The pupils should learn to recognize each year a few species of wild flowers by name as well as by sight. This may be accomplished in two ways, (1) by means of excursions to the woods a few times each year during the spring and summer months, and (2) by having occasional observation lessons in the school-room based upon the flowers gathered for the school-room bouquets. Both methods are to be recommended, but it must be borne in mind that a wilted, lacerated flower has no interest for a little child.

LESSON IN OUTLINE

BLOODROOT

Plants are always most interesting when studied in their natural environment, and this is one reason why the school excursion deserves the highest commendation as a method of studying wild flowers. When studying wild flowers out-of-doors, the pupils should notice what seems to be the favourite or usual location for the particular species under consideration.

Have the pupils observe the following about the bloodroot:

It seems to prefer fairly dry, rich soil, on or near a hillside. It opens its beautiful white blossoms early in the spring, as if to enjoy the bright sunshine before the trees put out their thick coat of leaves to shade it. It, like many another early spring flower, comes into bloom so early in the spring because it got ready the summer before. The teacher should carefully dig up a specimen—root and all—as young pupils cannot be depended on to get up all of the underground part. Note the large amount of plant food stored up in the underground stem, how the flower was protected before it opened out, and what becomes of the protection. Note the peculiar beauty of the snow-white blossoms with their yellow centres, and how beautiful they look as they nestle amongst the handsome green leaves with their pinkish-tinted stems. Wound the root, and notice the reddish, bloodlike juice whence the plant derives its name. Indians sometimes use this juice for war-paint, and some mothers give it to their children on sugar as a cure for coughs and colds.

Other wild flowers suitable for Form I are buttercup, spring beauty, dog's-tooth violet, hepatica, and trillium.

If there is a corner of the school ground that is partly shaded, and if the soil is fairly mellow and moist, some of these wild flowers should be transplanted there where they will grow well and can be seen every day during the blooming period.

The leaves and flowers of the bloodroot and the above-mentioned wild flowers can be used for drawing.

CORRELATIONS

Oral and written descriptions of the flowers studied afford suitable exercises in language and composition.

INSECT STUDY

CECROPIA, OR EMPEROR-MOTH

The larvæ of this, the largest of Canadian moths, may be found early in September, as they wander about in search of a suitable branch upon which to fasten their cocoons. If the pupils are not successful in finding the larvæ, the cocoons can be found after the leaves have fallen, because their size makes them conspicuous. The only difficulty in finding them is due to their being of the same colour as the withered leaves, so that they are easily mistaken for the latter.

The pupils should be directed to look carefully at what appears at first sight to be a withered leaf attached to a tree or shrub, and in this way many cocoons of various moths will be found.

Observe.—The large size—from three to four inches long; the greenish colour; the stumpy legs; movements, as walking, feeling, clinging; the rows of warts, and short, stiff spines on these; the feeding habits, biting or sucking; eggs of parasites, for frequently these are found on the larvæ.

Place the larva in a box covered with gauze, and observe the spinning and weaving of the cocoon.

From what part of the body is the silk obtained? With what organs are the threads placed in position? What part of the cocoon is made first and what part is made last? What time is required for making the cocoon? How is the cocoon fastened to the tree? What provision is made in the cocoon for warmth, for protection from birds, for shelter from rain?

Cut open a cocoon and examine the pupa, noting the mummy-like case on which can be seen the impressions of the wings developing within.

If the cocoon is kept in the vivarium in a cool place, so that the conditions may be as nearly as possible like the natural conditions, the adult moth will emerge about the first of May. In April the cocoon should be wetted occasionally, as it would be if exposed to rains; this ensures more perfect development of the insect.

Observe.—At what part of the cocoon the moth makes an opening; the slow spreading and strengthening of the wings; the size and coloration of the moth; the feathery feelers; the position of the wings and sucking mouth parts when at rest.

Require the pupils to make drawings of the cocoon, larva, and adult.

The promothea moth, whose cocoons are common on lilac bushes, may be studied in the same way as the emperor.

Reference.—Silcox and Stevenson: ***Modern Nature Study***

DRAGON-FLY

The larvæ of this insect may be obtained in May or June by scraping leaves, weeds, and mud from the bottom of ponds and allowing the mud and water to settle in a pail or tub. The larvæ may be distinguished from other aquatic creatures by the long insect-like body, three pairs of legs, and the "mask"—a flap with pincers at the end. This mask can be turned under the head and body when not in use, or it can be projected in front of the larva for catching prey. At the rear end are three tubes, which fit together to form the breathing tube.

The pupils should observe the above features, and also the movements, seizing of prey breathing, moulting, semi-resting or pupa stage, at the close of which the pupa climbs up a reed or stalk of grass and bursts the skin from which the adult emerges.

The pupils should put into the aquarium various kinds of insects and decide what foods are preferred by the larva and the adult.

Observe.—The size, length of body, movements in flight, lace-like wings, and insect-killing habits of the dragon-fly.

Should dragon-flies be protected? Give reasons. Are all dragon-flies of the same size, build, and colour? At what time of year are dragon-flies most numerous?

Reference.—Silcox and Stevenson: *Modern Nature Study*

OTHER CONSPICUOUS INSECTS

The potato-beetle, giant water-bug, eastern swallow-tail butterfly, and promothea moth are insects suitable as types to be studied by the pupils of Form I. The giant water-bug is the large, broad, grayish-brown insect that is found on the sidewalks in May and June mornings. (For information on the eastern swallow-tail and promothea see Metamorphosis, in Butterfly and Moth Collections.)

BIRDS

Bird studies for Form I should be limited to observations made directly upon a few common birds, such as the robin, house-sparrow (English), song-sparrow, flicker, house-wren, crow, bronzed grackle, and meadow-lark. These are easily reached by the pupils of every rural and village school, and the purpose of the lessons should be to

teach the pupils to recognize these birds, and by making use of child interest in living active creatures, to develop their interest in birds.

THE ROBIN

FIELD EXERCISES

I

Observe the robins and find out the following things:

1. Are all robins of the same colour? If not of the same colour, what difference do you note?

2. Does the bird run or hop? Imitate its movements.

3. Listen to its song. Is it sweet or harsh? Is it loud or low? Is it cheerful or gloomy?

4. Watch the robin as it moves along the grass and learn how it finds out where the worms are.

To the teacher.—The pupils should be given a few days in which to find out answers to these questions, and at the end of that time the answers should be discussed in the class.

Male robins have more pronounced colours than female robins. The beak is yellower, the breast is brighter, the back and the top of the head are darker. Robins both run and hop. The sense of sight of the robin is very acute, but its sense of hearing is even more keen. The bird may be observed turning its head to one side to listen for the sound of a worm which is still inside its burrow.

II

A second set of exercises may now be assigned which will demand a more detailed study of the bird, namely, a study of the size, colour, form of body, manner of flight, and length of beak.

III

THE NEST, EGGS, AND YOUNG

1. Find out various places in which robins build their nests. In what ways are these places all alike? Examine the materials of the nest and find out why the nests are built in the kind of places in which they are found.

2. Describe the eggs.

3. What kinds of food do the parent birds bring to the young? Does the father bird aid in bringing food to the young?

To the teacher.—The nests are found in well-sheltered parts of apple trees and evergreens, in sheds, under ledges of roofs, and in other sheltered places. The nests, since they are composed largely of mud and grass, would easily be washed away if exposed to rain storms. The food brought to the young consists of worms and insect larvæ, and the father bird is very industrious in helping to take care of his family. It is the father bird that sings, and the mother bird devotes all her energies to working and scolding.

THE SONG-SPARROW

FIELD EXERCISES

In early March, when the streams are just beginning to break from underneath the ice and spots of ground peep here and there through the snow, assign to the pupils an exercise such as the following:

Watch for a small, gray-brown bird which perches near the top of a bush, or small tree, and sings the "Tea-kettle Song".

Try to interpret the song in the words:

"Maids! Maids! Maids! Put on the tea-kettle, tea-kettle, tea-kettle, tea-kettle, tea-kettle-ettle."

Is the song bright and cheerful or dull and gloomy? Does the bird sing this song often?

Approach close to the bird. Are there any stripes or spots on its breast or head?

Describe the flight of the bird from its perch, when it is disturbed.

To the teacher.—It is possible for the pupils to distinguish the song-sparrow by means of the above exercises. It is one of the first birds to return in the spring, and, as it is a lusty singer, it will attract the attention of all who are looking for birds. The dark brown spot in the centre of the breast is a distinguishing mark, and the more observant will find the three ashy-gray stripes on its head and the dark line through the eye.

When disturbed, it does not rise into the air, but flies downward and disappears with a swish of its tail. The nest is usually built on the ground or in a low bush or tree. It is composed of grass, fine roots, or weed stems, and lined with fine grass or hair. The eggs are usually four or five, but sometimes there are as many as seven. They are white with a greenish-blue tint and are closely spotted with brown.

CLASS-ROOM LESSON

Discuss with the pupils the observations that they have made on the field exercises.

Generalize as to the similarity of the places in which the pupils have seen the sparrow singing, and as to the times of day in which the bird sings.

Teach the marks of identification which some have discovered, using for this purpose pictures of the bird or black-board drawings; and encourage those who have not yet seen the song-sparrow to try again and to secure the assistance of those who have succeeded.

Compare the size and form of the song-sparrow with that of the house-sparrow (English).

Tell the pupils the great value of the bird in killing cutworms, plant-lice, caterpillars, ground-beetles, grasshoppers, flies, and other insects. It also helps to prevent the spread of weeds by eating thousands of seeds of noxious weeds.

Assign the pupils some other things to discover, as for example: Through how many months of the summer does the bird sing? Find the nest. Why is it hard to find? Describe the eggs, as to size, colour, and number. Do not disturb the nest and do not visit it very often.

To the teacher.—Base lessons in bird study upon the English sparrow, flicker, wren, and meadow-lark.

THE SHEEP

PROBLEMS FOR FIELD WORK

How do sheep find one another when they have become separated?

How old are the lambs before they can keep up with the old sheep when running? What fits the lamb for running so well?

Watch the lambs when they are playing, and find out whether they play:

1. I'm the king of the castle.
2. Follow the leader.

Find out by watching a flock of sheep what is meant by "Men follow one another like a flock of sheep".

Describe how sheep move when they are going very fast.

Why should sheep be kept in a well-ventilated building that protects them from snow and rain but is not very warm?

To the teacher.—Each movement, habit, and instinct implied in this exercise is explained by the life of the wild sheep. Their natural home is in the mountain, and their swift movement is that of bounding from rock to rock as they follow the strongest and boldest (their leader) to a place of safety. The legs of the lamb grow rapidly, beyond all proportion to the rate of growth of the body, so that within two weeks after birth the young lamb is almost as strong of limb and fleet of foot as its mother. In their games the lambs are fitting themselves for their place in the flock, and these games very much resemble those named in the exercise.

CHAPTER VI

FORM II

AUTUMN

BULB PLANTING OUT-OF-DOORS

Tulips and daffodils (narcissus) are the most suitable bulbs for out-of-door planting. The best varieties for out-door culture are usually designated in catalogues. Bulbs should not be planted in individual plots, but in borders and ornamental beds. The latter should not be placed in the centre of a lawn, as is frequently done. Bulbs should be planted before the last of October.

BEDS FOR GROWING BULBS

To make a bulb bed, throw out the top soil to a depth of eight or nine inches, put about three inches of well-rotted stable manure in the bottom, and cover it with about three inches of the soil which was thrown out. Rake the plot level and then place the bulbs about eight inches apart on the top of the soil, arranging them in any design chosen. Cover them with the rest of the soil and rake it level. There will be about five inches of soil over the bulbs. When a solid crust has formed over the bed, put on a covering of leaves, straw, or branches of evergreens, and some pieces of boards to hold them in place. This covering does not protect the bulbs from freezing, but prevents too rapid thawing out in the spring. This cover-

ing should remain until the tips of the bulbs are showing above ground, when it should be removed. Ordinarily the bulbs may be left a second year before digging up. They should then be reset or replaced with new ones, and the bed made and fertilized as before.

In clay soil the bulbs should not be set quite so deep as in sandy soil, and the bulbs have better drainage about their roots if a handful of sand is placed under each bulb in planting.

Crocus bulbs may be planted in clumps anywhere about the grounds or borders by simply making a small hole about five inches deep, dropping the bulb in, and covering it. Lily of the valley grows best in partial shade in some unfrequented corner.

PLANTING OF BULBS INDOORS

Read again the instructions given under this heading in Form I work, regarding soil, planting, and care. The Chinese sacred lily and trumpet narcissus may be chosen for the pupils of this Form. The narcissus, also called daffodil, may be held back until early spring if kept in a cool, dark cellar, but the Chinese sacred lily, which is also a variety of narcissus, comes into bloom from four to six weeks after planting. It is usually grown in water in a bowl of suitable size. Place a few pieces of charcoal in the bottom of the bowl, set the bulb upon them, and pack coloured stones and shells around it as a support. Keep the bowl about two thirds full of water and set it in a warm, sunny place. It does not need to be set in the dark, as is the case with other bulbs. These may also be grown in soil in the same way as other varieties of narcissus. When blooming is over, the bulbs may be thrown away, as they cannot be used again.

GARDEN WORK

(See Autumn work for Form I.)

The pupils in Form II should be given more responsibility with reference to the care and management of their garden plots. If they have had a couple of years in gardening while in Form I, they will have gained sufficient knowledge as to the needs of plants and sufficient practice in garden craft to do a certain amount of work quite independently. The boys of Form II are able, with suitable garden tools, to do all the work needed in the management of their own plots and may even be allowed to do some of the harder work for the girls of their Form.

SEED SELECTION

Besides the usual work of weeding, cultivating, and harvesting of their crops, the pupils should undertake some work in seed selection. This work not only results in the improvement of the plants grown from year to year, but also helps to train the pupils in painstaking observation and the discerning of minute points of excellence. The ambition to produce, by careful selection and thorough cultivation, a grain or flower better than has been, is aroused, and, as the pupil's interest increases, his love for the art increases and his efforts meet with greater success.

The teacher should aim from the first to use only the best available seed even if the cost be greater. He should send for a number of catalogues and carefully choose those varieties of seeds that possess evident merit for the purpose intended. In the case of flowers, the pupils should be asked to decide what individual plants showed greatest excellence, and these should be marked, and the seed from

them preserved for next season's planting. When the flower is in full bloom, a small string tag should be tied to the flower stem (string tags can be got from a local merchant). On this tag should be written in lead-pencil the name of the species, the shade, and date of flowering. These flowers should be left to ripen thoroughly, and then the seed picked and sealed up in small envelopes, which the pupils should make as part of their manual training work. The date on the tag should be transferred to the seed envelope.

STORING SEEDS

All the envelopes should be collected, placed in a mouse-proof box, and stored in a cool, dry place until time to plant in the spring. Small bottles are excellent for holding seed and safer than envelopes. If such selection is carried on systematically, it will result in an increase of yield and of quality not to be equalled by even the best seed that the markets have to offer. Thus the school garden may become the centre of interest for the community. Seeds of good varieties can be distributed to the ratepayers, and the standard of gardening and horticulture raised. Here, as elsewhere, much—almost everything—depends upon the teacher's interest and ability to lead as well as to instruct.

HARVESTING AND STORING OF GARDEN CROPS

As soon as the vegetables reach their best stage of development, they should be taken from the garden by the owner. All dead plants and refuse should be removed and covered up in a compost heap. The boys of this Form should also assist in doing part of the general work of the school garden. They might take up from the

garden border such tender plants as dahlias, gladioli, and Canna lilies. These should be dried off and stored in a cool, dry cellar. If the cellar be warm, it is necessary to cover the bulbs with garden soil to prevent their drying out too much.

CLASS-ROOM LESSON

The pupils are led, through conversation, to state their experiences and observations. The teacher assists them in interpreting their observations and organizing their knowledge and stimulates them to thoughtful search for further information.

Discuss with the pupils such questions as:

What are people busy doing on their farms and in their gardens at this time of year? Why do they harvest and store the wheat, oats, corn, potatoes, and apples, etc.? Are there any countries in which people do not need to gather in the grains, vegetables, and fruits?

The discussion of these questions will direct their thought to the need of storing sufficient food for animals and for man to last through the winter, when these things do not grow. They must be gathered to protect them from destruction by storms of wind and rain and the severe frosts of winter. People who live in very warm countries find foods growing all the year round, and they do not need to prepare for winter, but these people are always lazy and unprogressive.

Discuss the means taken to protect the various crops, as follows:

Why can grain be kept in barns or granaries or in stacks? Why can apples, turnips, and potatoes not

be kept in the same way as grains? What are the conditions that are best suited for keeping the latter products? Name some kinds of crops that cannot be kept in any of the ways already discussed. Why can they not be kept in these ways?

These discussions will develop the idea of the necessity of keeping apples, potatoes, and turnips, in cellars, root-houses, and pits, where they cannot freeze, but where they are kept at uniformly low temperatures which are as close as possible to their freezing points. The air must not be too dry, as dryness causes them to shrivel up. In dry cellars they should be covered with fine soil. Very delicate fruits, such as cherries, grapes, peaches, plums, strawberries, etc., can only be kept for a length of time by preserving or canning them.

Correlate with lessons in Household Management on preserving and canning.

FALL CULTIVATION

When the garden has been finally cleaned out, the plot should be spaded up and left without raking. Clay soil especially is much improved in physical qualities by thus being exposed to the air and frost. All garden tools should receive a special cleaning up before storing for winter.

GARDEN STUDIES

The observational studies suggested under this head for Form I will be followed also in Form II. The pupils of Form II will be expected to make more critical observations in connection not only with the plants growing in their own individual plots, but also with those plants

which other pupils have been growing. They should give some attention also to the plants in the perennial flower border.

GARDEN RECORDS.

In this Form the pupils should begin to make garden records on such points as the following:

1. Description of the plant—size, habit of growth, kind of leaves and their arrangement, date of flowering, form, size and colouring of the flowers, points of merit or the reverse, description of the seed and how scattered, how disposed of, and the value.

2. The work done in the garden from day to day, with dates.

3. The effect of rain, drought, or other weather conditions on the growth of the plants.

4. What insects were seen visiting the flowers and what they were doing—whether beneficial or harmful.

5. What birds or other animals were found frequenting the garden. (See Animal Studies, pp. 30, 96, 217.)

6. What plants suffered from earliest frosts; what from subsequent frosts; what ones proved to be most hardy, etc.

7. What plants the pupils like most in the garden, and what ones seem to suit the soil and weather conditions best.

The pupils in this Form, by direct observation, should come to appreciate the development of the fruit and seed from the flower. Their work in seed selection, based upon the excellence of the flower, helps to ensure this line of observation.

CORRELATIONS

Art: Drawing of leaves, flowers, and vegetables, in colour when possible.

Arithmetic: Calculations as to dimensions, number of plants, number of flowers on a plant and seeds in a flower, value of products of flowers and vegetables. Cost of seeds, fertilizer, and labour, gross and net proceeds. Statement showing the above.

Composition: General connected account or story of the work done and the things learned during the season, as taken from the garden diary and from memory.

Exercises in writing and spelling, as suitable seat work.

Geography: Weather observations, as related to the garden work and to plant growth. Comparison of the soil of the garden with other samples from the district, as to composition and origin. Direction, as related to the paths or walks in the garden.

Map drawing: Plans of plots and of whole garden and grounds, represented on sand-table, paper, or blackboard. Map drawing on a horizontal surface is best for the first year or two.

The products of the garden, as compared with home products, as food supplies for man and beast.

Manual Training: Making of seed envelopes and boxes, modelling in clay of fruits and vegetables.

CLIMBING PLANTS

Observe particularly the sweet-pea and morning-glory.

Consider the following points:

1. Advantages gained by climbing, such as securing of more light, production of many leaves and flowers, and not so much stem.

2. Method of climbing—sweet-pea by tendrils that wind around the support; morning-glory by twining its

rough stem closely around its support. Do all morning-glory vines twine in the same direction? Find other vines that climb. Examine their modes of climbing.

3. Time of flowering and notes on how to plant.

Make drawings of the leaves and blossoms.

TREES

(See type lesson on trees under Form I.)

In this Form it is better to follow closely the development of one or two selected trees in school or on the home grounds than to attempt to observe many different species. Allow the pupils to choose their own trees for study and, if possible, have them select one at home and another near the school or on the way to school. The following points might receive attention: The name of the species, whence obtained and by whom planted if known; its approximate height, size, and age; its location, and the nature of the soil; its general shape, and whether or not influenced at present or at some time in the past by proximity to other trees; description and arrangement of its branches, leaves, and buds, its bark, flowers, and fruit; time of leafing out and blossoming; colouring and falling of leaves and ripening of seeds; the amount of growth for the year compared with that of previous years as shown by the younger branches; qualities of beauty and usefulness of the tree. Drawing exercises.

At least two visits should be made to the woods during the autumn months, one when the leaves of the trees begin to colour and another when the leaves have fallen. Consider the preparation made for winter in the woods and fields, the use of dead leaves in the woods as a protection to forest vegetation and as soil-making material. Bring

back samples of leaves and of leaf mould or humus for class-room observation. Note the effect of frost in hastening the falling of leaves—frost does not give the brilliant hues to leaves, as many people think. Consider the relationship of the forest trees to animal life.

STORING OF TREE SEEDS

Make a collection of nuts and other tree seeds, some of which should be put in the school collection and the rest planted in the garden or stored away for spring planting. The seeds of evergreens should be kept dry and cold, but other seeds, as a rule, are best packed in a box of slightly moist sand set in a cold place or buried in the ground.

A FLOWER

TYPE: NASTURTIUM

I

Teacher and pupils visit the nasturtium bed, where the flowers stand up boldly, surrounded by the shield-shaped leaves. A search for the young flower buds and for the very old flowers leads to the discovery that these are snugly sheltered under the shields.

The greenish-yellow calyx, which is closely wrapped around the bud, is next examined. Its name is given, and its use as a protector is discussed.

The strong seed cases are opened and the seeds are discovered. The pupils are instructed to watch the insects that visit the bright flowers. Name the insects. Describe their movements. Catch a few and find the yellow powder on their furry little bodies and legs.

II

Each member of the class brings a flower to the schoolroom. The varieties of colours of the flowers are discussed. The cave-like form of each flower is noted. The velvety feeling of the corolla and the delicate perfume are likewise sensed by the pupils.

The pupils nip off the point of the cave and taste the nectar (honey), and thus learn why the insects visit the flowers. They next trace the course of the coloured lines on the corolla and find that they all point into the cave.

Continuing their explorations of the mouth of the cave, the pupils will discover the little boxes containing the yellow powder that the flower dusts upon the insects. The names *pollen* and *pollen boxes* are given.

The fringe on the edges of the leaves of the corolla for the purpose of preventing the insects stealing into the cave without receiving their baptism of pollen, is discovered.

The teacher should, at this point, give a brief explanation of the valuable work done by the insects in carrying pollen to cause seeds to grow in the next flower that the insect visits. The position of the tiny brush (stigma, but do not give this name) held up by the seed case for rubbing the pollen off the insect, should also be observed.

Summary.—Name and point out the parts of the flower (calyx, corolla, pollen boxes, seed cases).

What useful work do insects do for the flower?

What reward do they receive for their work?

What advertisements do the flowers put out for attracting themselves? (Bright colours, sweet perfumes, and honey)

Flowers suitable for lessons in Form II are nasturtium, larkspur, snap-dragon, morning-glory, and sweet-pea.

NOTE.—Botanical names should be reduced to a minimum.

SOIL STUDIES

(See *Soils* by Fletcher.)

Soil should have a place in a Nature Study Course because:

1. It is so closely related to life.
2. It lends itself so admirably to the experimental method.
3. It is so liable to be overlooked and considered as common and valueless.

KINDS OF SOIL

Gravel is composed of small, rounded stones of various colours, sizes, and shapes. Occurs in beds, generally mixed with sand. Get a sample and examine the constituents. Lead the pupils to see that the pebbles are the result of the breaking up of larger rocks. What has made the corners smooth and rounded? What use is made of gravel? Have the pupils find some gravelly land.

Sand is composed of small angular pieces of hard rock. Have a few samples from different places brought to school, note fineness and colours, examine with a lens and note resemblance to pieces of broken stone. Draw a magnet through the sand and note black particles adhering, showing presence of iron in some form. Show the hardness by rubbing against the surface of a piece of glass. Sand is used for mortar, concrete, and glass. The chief sand-forming rocks are quartz and granite. Show pupils how to recognize these. Examine a sample of sand under a lens.

Clay. Note colour and odour of fresh sample. Dry and pulverize and note extreme fineness of the particles by rubbing between the fingers (an ounce of clay contains about four and one half million particles). Clay is made from crushed rocks, chiefly feldspars. Mix clay with a little water and note sticky character. Compare with sand in this respect. Which makes the best road in wet weather, gravel, sand, or clay? Note how hard the clay bakes after being moistened. Uses of clay—pottery, bricks, tile. Pupils should visit a brick- or tile-yard and watch the process of manufacture. In many parts of the world there are beds of clay of extreme fineness and whiteness, from which beautiful china is made.

Humus is decayed vegetable matter. Pupils should gather soil from the forest, bog, or marsh. Note dark colour. Examine carefully and see what you can find in it that is not in sand or clay.

Most of our farm land consists of these four soils mixed in various proportions, and it gets its name from the one that preponderates. Thus we have our sandy, gravelly, or clay *loams.* Humus is likely to be present in all fields, because vegetable matter grows, to some extent, everywhere; but freshly broken land, reclaimed swamps, and prairie lands are likely to be especially well supplied. The great value of humus in the soil will appear in later studies.

ANIMAL STUDIES

BIRD MIGRATION

(Consult ***Bird Life*** by Frank M. Chapman, and ***Bird Studies*** by G. A. Cornish.)

In the autumn, direct attention to the flight of wild ducks and geese and to the gathering into flocks of robins,

crows, bronze grackles, blue herons, sparrows, and other birds in preparation for migration.

Discuss with the pupils the reasons for migration, namely, scarcity of food, the cold, the snow. In the spring, the return is stimulated by the nesting instinct.

Note how the birds are guided—some, for example the ducks and geese, by their leaders, while others have no guides but their instincts.

In winter, require the pupils to observe the kinds of birds that are to be seen in the gardens, fields, orchards, and woods, having them note the scarcity of birds and the absence of many forms that are with us in the summer.

CORRELATIONS

Geography: By pointing out on the map the countries into which the birds go, namely, Central America, Brazil, etc.

Reading and literature: By interpreting

Where did you spend the dreary winter?
In a green and sunny land,
By the warm sea-breezes fanned,
Where orange trees with fruit are bent,
There the dreary time I've spent.

COMMON WILD ANIMALS

GENERAL METHOD FOR FIELD WORK

The best method for studying wild animals is to assign to each pupil some animal as his particular subject of study.

Begin by finding out from the pupils the wild animals that each one knows to be near his home, and assign to each pupil a number of problems on the animal which is most convenient for him to study.

In some cases, only one pupil will be studying a particular kind of animal, while in other cases several pupils may be studying the same kind of animal. The latter method has the advantage of giving opportunity for comparison of results. Differences should serve as stimuli to more careful observation, in order to verify or disprove previous conclusions.

The observations and inferences, together with drawings illustrating the animals, their homes, etc., are recorded in the Nature Study note-books. These are discussed in the class, verified or corrected, and supplemented by descriptions of lives and habits of the animals from nature writers or naturalists, such as Charles G. D. Roberts, Ernest Thompson-Seton, etc.

When pupils become interested in this form of study, they become nature students in the true meaning of the term. The pupil is brought into contact with the animal in its natural environment and, under these conditions, the natural habits, interests, and activities of the wild creatures are more likely to appeal to the sympathy of child nature than under any other method of study. The method has also the advantage of being one of original discovery, and consequently it trains in self-reliance and independence of thought.

Finally, since close and careful observation is necessary, the child learns that it is unwise to alarm the animal, and thus a better relationship between child life and animal life is fostered.

It may be objected that this method is slow and that little is accomplished. This may be true from the view-point of matter learned, but from the view-point of child training more can be accomplished from the study of a single living animal than from the study of a score of pictures or stuffed skins.

A second method that is recommended is the study of tame animals. By conversations with the boys of the school the teacher will find what tame squirrels, ground-hogs, raccoons, foxes, and other animals are available for class-room work. The possessors of these animals are usually quite willing to bring them to school for the class to study.

The movements, habits, food, and other topics, may be studied by direct observations guided by the teacher's questions or problems.

A third method and, unfortunately, the one which is in most general use, is the study of animals by means of stuffed specimens and pictures, supplemented by descriptions and stories by the teacher. These lessons may be called information lessons, but they are not worthy of the name Nature Study. Indeed, if conditions are such that it is the only method available for animal study, it is advised that the time be spent on other branches of the subject; but if living animals are made the basis of study, stuffed specimens may be found useful for identification and for confirming observations on minute structural features, colour, etc.

THE WOOD-CHUCK

The problems outlined below are intended to illustrate the plan of study suggested in the first general method. They are assigned to a boy who has discovered a ground-hog burrow, in order to direct him in his observations on the animal.

What is the kind of soil dug out in making the burrow? Why is this soil suitable for the burrow? What size of stones are dug out in burrowing? Are there more entrances than one?

By slowly approaching the animal, find out how close it will permit you to come. At what times of day does the ground-hog come out? Give reasons for its coming out at these times rather than at mid-day. Upon what does the animal feed? Describe the colour of the animal and find out any advantages in this colour. Observe the following actions: running, hiding, keeping sentry, and scouting.

Do more wood-chucks than one live in one burrow? When do the young wood-chucks first come out of the burrow? Describe their size, colour, and habits. Are wood-chucks ever seen during the winter? Do they use the same burrow year after year? Describe the sounds made by the animal. What injury does the animal cause to the fields?

Describe the fur, teeth, and claws, and show their relation to the animal's habits of life.

Dig out a burrow and draw a plan of it. Make pictures showing the various attitudes of the animal.

THE CHIPMUNK

FIELD EXERCISES

Describe the size, colour, shape, length of tail, and movements of the chipmunk. Compare with the red squirrel.

Have all chipmunks the same number of stripes?

Discover its home; method of carrying grain, nuts, or other foods; whether it is found most commonly on the ground, in trees, or among logs and stones. Try to tame it by placing food where it can reach it and, finally, try to have it feed from your hand.

Find out why there is no loose soil around the entrance to its burrow, whether more families than one live in one burrow, whether the chipmunk comes out during winter, or how early in the spring. Learn to distinguish the sounds of the animal, as expressing alarm, surprise, anger, playfulness.

To the teacher.—Chipmunks carry grain, etc., in their cheeks. Frequently these are so full that they must be emptied to permit them to enter their burrows. It is not uncommon for several to spend the winter in the same burrow, having a common storehouse connected by passages to the main burrow. These little animals are easily tamed and soon learn to take food from the hand. They are not hibernating animals, for they store food for winter, and though they are not asleep all winter, yet they rarely come out of their burrows while there is snow on the ground.

EASTERN SWALLOW-TAIL BUTTERFLY

No butterfly is more suitable for study by the Junior Forms than the Eastern Swallow-tail. It is one of the most beautiful and attractive of our butterflies and lays its eggs so accommodatingly on every carrot or parsnip bed that it gives ample opportunity for observation.

If possible, have the pupils observe the insect in the act of placing the eggs, one here and one there, on the under surface of the leaves of the plants, noting the busy movements; discuss the advantage of scattering the eggs, and also that of placing them on the under surface of the leaves.

If the egg placing cannot be observed, there will be little difficulty in finding the large yellow and green larva

with a head shaped like that of a miniature sea-horse. If the larva itself is not easily found, the leaves stripped bare of green blade and the droppings on the ground will reveal its presence.

Why was it difficult to see such a large, and now that it is seen, conspicuous object? Lead the pupils to notice that the yellow and green bands harmonize in colour with the green leaves and alternate streaks of golden sunlight.

Does the larva feed by biting or by sucking? How many legs has the larva? Cover the plant and larva with a paper bag, or inverted bottle, or a lamp chimney with a gauze top until the larva is full grown; or place the larva in a vivarium, feed it on carrot leaves, and observe its growth.

When full grown, the larva builds for itself a snail-shaped, fairly firm case, fastened by a slender girdle of silk to a piece of wood or other support. Keep this over winter, and in March, or early April, the black-and-blue-and-gold insect emerges.

Observe the movements of the wings in flight, the long tube with which it sucks honey from flowers, the three pairs of legs, the position of the wings when at rest; compare the structure with that of the larva. Make drawings of the butterfly and paint its colours.

CHAPTER VII

FORM II

WINTER

CARE OF PLANTS IN THE HOME

THE CARE of flowering bulbs, which was begun in Form I, will be continued in Form II. The growing of new plants from cuttings will now be taken up. In those schools which are kept continuously heated, potted plants may be kept throughout the year. The pupils will come to appreciate the plants' needs and learn how to meet them in the supply of good soil, water, and sunlight. The following points should be observed:

1. Good potting soil can be made by building up alternating layers of sods and stable manure and allowing this compost to stand until thoroughly rotted. A little sharp sand mixed with this forms an excellent soil for most house plants.

2. Thorough watering twice a week is better than adding a little water every day.

3. The leaves should be showered with water once a week to free them from dust.

4. An ounce of whale-oil soap dissolved in a quart of water may be used to destroy plant-lice. Common soapsuds may also be used for this purpose, but care should be taken to rinse the plants in clean water after using a soap wash.

5. Most plants need some direct sunlight every day if possible, although most of the ferns grow without it.

6. Plants usually need re-potting once a year. Many kinds may be set out-of-doors in flower beds in May and left until September, when they may be taken up and placed in pots, or cuttings may be made from them for potting.

7. A flower exhibition at the school once or twice a year, or at a local exhibition, adds to the interest.

8. The pupils should report to the teacher, from time to time, the progress of their plants and make many drawings showing their development.

TREES

In November or December make a study of Canadian evergreens, choosing spruce, balsam, and cedar if available. The pupils should learn to distinguish the different species by an examination of the leaves, buds, arrangement of branches, bark, seeds, and cones. The age of young trees can be determined by noting the successive whorls of branches. In this way also the age of the leaves may be determined. On some trees the leaves persist for seven or eight years. Evergreens are frequently used as Christmas trees and their branches for house decorations. On which species do the leaves persist longest? How do they compare with the pines? The leaves are always as old as the wood upon which they grow.

Have the pupils notice how the small leaves and horizontal branches resist the clinging of snow in winter. Each branch bends down enough to cause the snow to slide off on to the one next below, and so on, until it reaches the ground. The conical shape of the tree also facilitates this action of dislodging the snow. They will

also notice that these trees are well adapted to withstand wind, as the top part, which is most exposed to the wind, is much smaller and more pliable than the part next the bottom. The gum, or resinous covering, of the buds protects them from injury by rain or snow. Some kinds of pine, such as the pitch pine, have a great abundance of gum and turpentine. Resin and pine tar are made chiefly from this species. Heat a piece of pine wood—a knot or root is best. The gum will be seen oozing out of the wood. Pine torches were much used in the early days of settlement in Canada. Examine the gum "blisters" in the bark of the balsam tree. From this source the "Canada Balsam" gum of commerce is taken. The gum and resin in the wood and bark help to preserve the wood from decay.

COLLECTION OF WOOD SPECIMENS

During the winter months the boys may prepare specimens of wood for the school collection. These specimens should be cut green and dried. They should be uniform in length—not more than six inches—and should show the bark at one side. The side showing the bark should be two inches wide at most, six inches long, and running in a V-shaped, radial section toward the pith. A tangential section also shows well the annual layers. A piece of slab as cut lengthwise off a round stick is tangential. Also visit wood-working factories for specimens of rare or foreign woods. In securing these specimens, care should be taken not to mutilate trees.

RELATED READING

Winter is nature's quiescent period. Continuous active observation out-of-doors among the plants of the forest

and garden gives place for a time to indoor work and reflection. Pupils need time for reading and reflection, and no time is so opportune as the quiet winter season. During these months some time should be devoted to the reading of nature stories and extracts from magazines and books dealing with plant as well as animal life. Pupils should review their gardening experiences and discuss plans of improvement for the approaching spring and summer. Let them write letters to the Form II pupils of other schools where similar work has been carried on, giving some of their experiences in gardening and plant and animal studies. A certain Friday afternoon might be appointed for hearing the letters read which have been received in reply. Suitable short poems that have a direct bearing upon their outdoor studies should be read from time to time. Good pictures come in here also as an aid in helping the children to appreciate written descriptions. The first-hand observations made by the pupils will form a basis for the better and more appreciative interpretation of these literature selections.

THE DOG

CLASS-ROOM LESSON

Use the conversation method, since this is an animal that is well known to all the pupils. By natural, easy conversation with the pupils, encourage them to tell what they know about the usefulness and the other qualities of their canine friends.

The pupils know that some dogs are useful for hunting wild animals, others for driving or herding cattle and sheep, others for guarding their master's property, others for hauling sleighs and wagons, while others are of use as pets or playfellows.

Discuss with the pupils the qualities that make the dog so generally useful to us. In this discussion, guide the thoughts of the pupils to the qualities of faithfulness, loyalty to his friends, and docility—few animals are so easily taught. Note his strength and swiftness—he can continue in a race until he catches almost any other animal. Note also his bravery—for he does not hesitate to attack an animal many times larger than himself.

Short stories of the following type may be told, to illustrate the chief qualities of the dog:

A dog was trained to guard any article that his master placed under his charge, and not to permit any one to touch it until his master gave his consent. One day, when returning from the mill, the master placed a sack of flour inside the gate for a neighbour who had asked him to do so, and then continued on his way without noticing that his dog had taken charge of the sack. All through the afternoon of that day and through the long, cold night that followed, the faithful animal remained at his post. When the owner of the sack came next morning to get it, the dog, although numb with cold and famished with hunger, would not permit him to take the flour. Nor could the stout-hearted creature be persuaded either by threats or by coaxing, until his master was brought, when, at his first word of command, the dog bounded joyfully toward him.

Conclude the lesson by a short discussion of the proper care and treatment that should be given to dogs. The dog requires a fairly warm but dry kennel, with a soft bed of straw or rugs. The food should consist chiefly of porridge, milk, bread, biscuit, and a little meat. Only dogs that are running a great deal out of doors should be given much meat. The dog should be given bones to pick;

picking bones is as good for a dog's teeth as a tooth-brush is for a boy's.

OBSERVATION EXERCISES

By making observations upon your dog at home, find answers to these problems:

1. How does a dog hold a bone while he is picking it, and how does he get the meat off the bone?
2. Examine the dog's feet and find out:
   (1) Why he does not slip while running.
   (2) What protects the soles of his feet from injury as he bounds over rough ground.
3. Which is the sharper, a dog's eye or his nose? Watch how he finds his master in a crowd or finds an object that you have hidden.

CORRELATIONS

Language:

1. Require oral or written reproduction of the stories used in illustration in the lesson on The Dog.

2. Require the pupils to relate incidents from dog life that have come within their own experiences.

Art and Modelling:

1. A sleeping dog.
2. A dog waiting for his master.

LESSONS INVOLVING COMPARISON

It will be found helpful, both for increasing interest in the observations and for fixing the facts in memory, to study an animal by comparing its habits, qualities, and

physical peculiarities with those of another animal which is somewhat similar. Where differences are discovered, explanations of the differences should be developed in such a way that a tendency may be cultivated for interpreting the adaptation of structure to use and of life habits to surrounding conditions.

CAT AND DOG

Compare the movement of a cat when approaching its prey with the movement of the dog when chasing a squirrel.

Account for the difference.

The natural habit of the cat is to hunt alone and rely upon stealth, while dogs hunt in packs and tire their prey by running and by terrifying noises.

Other differences and their explanations, which the pupils should be led to discover are:

The dog is a more useful animal to man than is the cat.

The cat's body is longer and more slender, and this gives it greater suppleness in crawling and leaping.

The cat's eye is larger and the pupil is especially large at night, to enable it to see.

The cat's whiskers are longer; they help in guiding it at night.

The cat's tongue is rougher; it uses it for cleaning bones.

The pads on the cat's feet are softer, so that it can move more silently in stealing upon its prey.

The cat's claws are sharper, because it uses them for seizing its prey, while the dog seizes its prey with its teeth.

The dog is more faithful to its master because it is a more sociable animal. In its natural state every dog is faithful to the pack and to the leader; the cat is not a social animal, but is by nature solitary and independent.

The dog's sense of smell is keener than that of the cat, but its sense of hearing is less acute. Account for these differences from the animals' habits of hunting. Why does the cat bring home living animals to her kittens, while the dog buries dead animals? The cat trains the kittens to approach by stealth and then to pounce on the right spot. Wild animals related to the dog bury the "kill" which is too large to be eaten at one meal.

EXPERIMENTS FOR ASSISTING IN THE STUDY OF THE CAT

1. Gently scratch with a pin at some distance from where a cat is lying. What do the movements of the cat indicate?

2. Put a fish in water and watch a cat trying to get it.

3. Sprinkle water on a cat's fur and find out why she dislikes being wetted.

4. Attach a ball to a string and move it near a cat. Describe the movements, as stalking, springing, seizing, retreating.

5. Put some catnip in a room out of reach of the cat and observe the movements of the animal.

Nearly all children make pets of the house cat, and although the cat is a domestic animal of thieving propensities and an enemy of birds, yet it would be unwise to teach the younger children any enmity toward her. The

establishment of sympathy with animal life, the humanizing effect upon child nature of having a kitty for a playfellow, will offset many times over the amount of depredation of which she may be guilty.

COMPARISON OF THE HORSE AND COW

Assign problems for the pupils to solve by observations made upon the animals in the field or farmyard.

1. What features of build give to the horse greater speed than the cow?

2. Compare the movements of the heads of the horse and cow while cropping grass. Account for the difference.

3. How has nature fitted the cow and the horse respectively, for defence?

4. Which end of the body does the horse raise first when it is getting up? Which end of its body does the cow raise first? Account for the difference.

To the teacher.—The horse is the swifter and more graceful runner because the body is less bulky and the legs are longer and straighter. In cropping grass the cow pushes its nose forward and breaks the grass off, a process which is made necessary because the cow has no upper front teeth. The strong, sharp horns, short, powerful neck, and heavy shoulders are an efficient equipment for the cow's method of defence, while the long, strong legs and powerful hindquarters of the horse enable it to deal terrific blows with its hard hoofs. The horse rises upon its forelegs before raising the rear of its body, while the cow raises its hindquarters first.

THE SQUIRREL

FIELD EXERCISES

Problems :

Is it true that squirrels have little roads along the ground?

Does the squirrel come down a tree head foremost, or tail foremost?

Are a squirrel's feet close together or wide apart when it is climbing?

How many kinds of feeling can a squirrel express by its voice?

How does a squirrel open a nut?

Examine a squirrel's tracks in the snow; which footprints are in front?

Try to gain the confidence of a squirrel by never chasing it and by placing some favourite food for it.

CLASS-ROOM LESSON

A tame squirrel is very desirable for concrete study.

Describe the shape, size, and colour.

Find out how the legs and feet are fitted for climbing and leaping.

Compare the length of the tail with that of the body. Of what use is the tail in cold weather? Of what use is the tail in leaping?

Examine the teeth and find out how they are fitted for opening nuts; gnawing wood.

To the teacher.—The legs of the squirrel are short so that it can press its body close to the tree when climbing. The claws are strong and sharp and the hindquarters are very strong, and are, in consequence, well fitted for leap-

ing. The tail of the squirrel is very long and bushy and serves as a fur for keeping the squirrel's nose warm in winter. The tail is also used for balancing the body when the animal is leaping from bough to bough.

The front teeth of the squirrel are very large and strong and are shaped like chisels.

WINTER BIRDS

In the class lesson on winter birds, take up the birds that the pupils have seen, such as chickadee, blue jay, quail, ruffed grouse, hairy woodpecker, downy woodpecker, great horned owl, house-sparrow, snow bunting (snow bird), pine grosbeak, snowy owl, and purple finch. The four latter are to be noted as winter visitors. Use pictures for illustrating these birds. The habits and winter food of the birds should also be described from the view-point of how these adapt the birds for spending the winter in a cold climate. Direct the children to look for grosbeaks in the pine and rowan trees, where they may be seen feeding on the seeds. The ruffed grouse (commonly called partridge) feeds on the buds of trees in winter; its legs and feet are thickly covered with feathers in winter but are bare in summer.

FIELD EXERCISES

Arouse the interest of the pupils by a conversation of about three minutes on birds that they have seen during the winter, and assign the following exercise:

Take a walk through the orchards and woods on a bright winter day. What birds do you see? What are these birds doing? Are they found singly or in flocks? What bird sounds do you hear?

CLASS-ROOM LESSON

The method is conversational and based upon the observations made by the pupils during the field exercises.

The discussion would involve the winter habits of some of the more common birds, as, for example, the ruffed grouse (commonly though incorrectly called the partridge). This bird takes shelter from the winter storms in the centre of a dense evergreen or burrows deep into a snow bank. The close covering of feathers upon its feet serves not only to keep the feet warm, but also as snowshoes. In the evenings these birds may frequently be seen in the tops of such trees as maple, birch, cherry, and poplar, the buds of which form the greater part of their winter food.

The snow bird, or snow bunting, is another bird commonly seen in winter. Flocks of these hardy little winter visitors frequent the roads and fields during winter. Its summer home is in the far north.

Another visitor from the sub-arctic regions is the pine grosbeak, which is often mistaken for the robin, for these two birds are nearly equal in size. The carmine colour of the upper surface of the male grosbeak distinguishes it from the grays and blacks of the upper part of the robin. The grosbeak frequents the rowan trees.

The bird sounds which attract attention during the winter are the cheerful notes of the chickadee, the bold clarion call of the blue jay, and the sharp tap, tap, tap, of the downy woodpecker.

The downy woodpecker and the chickadee have snug winter homes within hollow trees, but, when the weather is favourable, they go about searching industriously for the eggs and larvæ of insects that infest forest and orchard trees.

CORRELATIONS

Literature:

Do you know the chickadee,
In his brownish ashen coat,
With a cap so black and jaunty,
And a black patch on his throat?

Language: Write a story about the winter experiences of a downy woodpecker.

Geography: Describe the summer home of the snow bird.

ANIMALS OF THE ZOOLOGICAL GARDENS

Pupils who have an opportunity to visit museums or zoological gardens will observe more intelligently if the visit is preceded by such a discussion in the class-room as will arouse their curiosity respecting the habits, movements, and adaptive features of the animals about to be studied.

CLASS-ROOM LESSON

Name the kinds of bears you have seen or have read about. What kind was the largest?

Are all bears wholly flesh-eating animals? Find out what food the keepers give these animals.

What features give to the bear his great strength? Observe the length of his "arms", teeth, claws.

Does the bear climb a pole in the same way that a boy does?

Read:

Rogers ..... Wild Animals Every Child Should Know. McClelland, Goodchild, & Stewart. 50 cents.

Thompson-Seton ..... Wild Animals I Have Known. Briggs. $1.50.

Roberts ..... Children of the Wild. Macmillan. $1.35.

CHAPTER VIII

FORM II

SPRING

GARDEN WORK

THE PUPILS have now arrived at an age when they are able to do most of the work of preparing and planting their own plots. The seeds have been selected and placed in readiness for planting long before the ground is ready. The plans for the garden and the varieties to be sown in the different plots have likewise been arranged. Fertilizers, lines, tools, and labels are made ready for use. With such thorough preparation the making and planting of the garden becomes a pleasure and a delight to both teacher and pupils. The garden diary should begin as soon as the snow disappears from the garden and be continued until all the work is completed in the autumn, and the garden again blanketed in snow.

The main points to be safeguarded are:

1. Thorough cultivation and fertilization.

2. The best available seed carefully planted. Guard against thick sowing and deep covering.

3. Frequent cultivation and careful thinning while the plants are quite small.

4. Vigilance in detecting the appearance of cutworms or other injurious insects and promptness in combating them.

5. Protection of the garden against injury from dogs, pigs, poultry, and English sparrows.

6. Failure of some plots, through the owner's absence from school for long periods.

COMBATING GARDEN PESTS

CUTWORMS

In gardens where the soil is light or sandy, cutworms are most likely to be troublesome. Watch for them about the time that the plants are nicely above ground. They come up at night and cut the young plants off just above the ground. They are about an inch long, gray and brown, fat and greasy-looking. To protect the plants put one quarter of a pound of paris-green with twenty-five pounds of slightly moistened bran, using a little sugar in the water and stirring the paris-green into the bran very thoroughly. If too wet, add more dry bran. It should crumble through the fingers. Sprinkle a little of this mixture with the fingers along the row close to the plants. The cutworms eat this poisoned bran quite readily. Care must be exercised in using this poison lest poultry should get at it. On the other hand, poultry should not be allowed to get into the garden. Wrapping a piece of paper around the stem when transplanting young plants will help to save them from cutworms.

ROOT MAGGOTS

Root maggots of cabbage, radish, and onions are the larvæ of flies similar in appearance to house-flies but a little smaller. When the plants are young, the flies lay their white eggs on the stem close to the ground. When the eggs hatch, the larvæ crawl down under the ground

and cause the plants to decay. The wilting of the leaves is the first sign of the trouble. Prevention is better than cure in this case. Dust some dry white hellebore along the rows of onions or radishes and around the cabbage plants; or, for radishes, make a decoction of insect powder (Pyrethrum), four ounces to one gallon of water, and pour around the root, using half a teacupful to each plant.

FLEA-BEETLES

The turnip flea-beetle quickly destroys young plants of the cruciferæ family by eating their leaves. Paris-green, one part to twenty parts of pulverized gypsum (land plaster) dusted on the plants while damp, helps to destroy these insects.

To the teacher.—When pupils who are absent find it impossible to give the necessary attention to their garden plots at school, they should turn them over to other pupils or to the teacher, who may at his own discretion use the produce for purposes of general garden revenue.

SEED GERMINATION

The seeds for the garden should be purchased quite early in the spring. As the planting of poor seed is often the cause of much disappointment, it is well to test the germinating power of the different varieties to be planted. The pupils of this Form should test especially those varieties which they have chosen. To do this, place about twenty-five seeds in a germinating dish, which may be made as follows: Take a deep plate, such as a soup plate, fill it about half full of moist sand, and spread over this a piece of moist cloth. Put the seeds upon this cloth and cover them with a second piece of damp cloth or moss.

To prevent drying out invert over it another plate and set all in a warm dry place (about 70 to 80 degrees F.). After a few days count the number of seeds that have germinated. This will be a guide in planting as to how thick the seed should be sown.

The pupils should watch the development of germinating grains, such as corn and beans, germinated in the same way as in the last exercise. The following points may be observed:

1. The first change noticed. (Swelling of the seed)
2. The appearance of a growing shoot and its direction. (Root)
3. The second shoot and its direction. (Stem)
4. The appearance of the first pair of leaves.
5. The appearance of root-hairs and rootlets.
6. What becomes of the main body of the seed.
7. How the second pair of leaves differs from the first pair.
8. Length of time required to produce the first pair of leaves.

Pupils may be taught the conditions that are necessary for the germination of seeds by means of a few simple experiments which can be carried on in the school-room.

1. In February, plant a few seeds of the pea, or oat, or wheat, in a box of soil, and place the box outside the school window.

2. In April, plant a few seeds similar to those used in No. 1, in a box of perfectly dry soil, and set the box inside the school window.

3. Plant a few seeds similar to those used in No. 1, in a jar containing soil that is kept very wet, and set the jar in the school window.

4. Plant a few seeds, similar to those used in No. 1 in a box containing soil that is moist but not wet, and set the box in the school window.

5. Plant seeds as in No. 4, except that the box is kept in a dark cupboard.

Compare the results of the above with reference to:

1. The number of seeds that germinate.
2. The growth and condition of the plants.

Form conclusions with reference to:

1. The conditions that are required for seed germination.
2. The benefits of well-drained soil.

Pupils make drawings showing the boxes and plants.

PLANTS FOR INDIVIDUAL PLOTS

The pupils of this Form should not attempt to grow more than two varieties of flowers and two of vegetables. Of flowers, mixed asters and Shirley poppy are to be recommended, the poppy being an early blooming flower and the aster late blooming. Carrots and radishes are desirable vegetables, as the carrot matures late and the radish early. Two or three crops of radishes may be grown on the same ground in one season. Besides these, a few others should be chosen for special study, such as the potato, onion, corn, and sunflower.

STUDIES BASED ON OBSERVATIONS OF GROWING PLANTS

Attention should be given to the growing habits of plants, the size and rate of development, the method of multiplying and propagation, and the part used for food.

The potato is a tuber which is nothing more than the swollen end of an underground stem; the onion a bulb composed of the bases of thickened leaves; the corn an example of a jointed stem or grass having two kinds of flowers, the tassels being the staminate flowers and the cob with its silk the pistillate ones; the sunflower an example of a compound flower made up of many little flowers each of which produces a single seed.

Observations should also be made upon the progress in germination of the nuts and other tree seeds collected in the fall. When the seeds fall from the elms and soft maples in the spring, some of them should be collected and planted in the forestry plot, or nursery.

PLANTING AND CARE OF SWEET-PEAS

1. Sow as early as possible in spring.

2. Sow on well-drained land and never in the shade or near grass. Grass roots rob the sweet-pea roots of water.

3. Use a small amount of fertilizer—well-rotted manure spaded deeply into the soil. This is best done in the autumn.

4. Make the trench in the fall about five or six inches deep.

5. Plant in a trench in April from half an inch to an inch apart.

6. Cover from three inches to four inches deep.

7. Water thoroughly once or twice a week, and have the soil lower along the row than farther out, so as to hold the water.

8. Put a mulch of lawn clippings along the row on each side to prevent drying out.

WILD FLOWERS

Arrange an excursion to the woods when the spring flowers are in bloom. Keep a flower calendar, showing:

1. The date when a plant was first found in bloom
2. The name of the plant
3. Place where found
4. Name of the pupil who found it.

When in the woods discuss the following points:

1. Why these wild flowers come into bloom so early in spring. They have a large supply of food stored up from the previous summer.

2. Dig down with a trowel or heavy knife and find this storehouse of food. It may be in the form of bulb, corm, or rhizome.

3. The blooming of the spring flowers in the woods before the leaves of the trees reach their full development, thus taking advantage of the sunlight.

4. Mark a few clumps or individual plants and visit them again after a month. Look for the growing fruit with its seeds.

5. The leaves of the hepatica seen at the time when the blossoms appear are leaves which grew the previous season. Dig up a plant and notice the new leaves starting.

6. The kind of soil each seems to grow best in and the amount of light it receives.

7. Have the pupils examine the flowers and leave them growing. They should gather a few for the school-room.

8. Have the pupils write a short account of their visit to the woods. Have them make drawings of the different flowers collected.

Dig up a few specimens of wild flowers and transplant in a shady corner in the grounds or school garden. The following varieties are suggested for special observation and study: hepatica, violet, anemone, columbine, Indian turnip, marsh marigold.

Teach one or two lessons on wild flowers, similar to the lessons illustrated for the nasturtium.

WEEDS

Pupils in this Form should learn to identify most of the weeds that are found in the garden plots and a few of those commonly found in fields and along roadsides. The large bulletin *Farm Weeds,* published by the Dominion Department of Agriculture, will be of great value in helping to identify the weeds and also in gaining useful information regarding them and the best means of eradicating them.

The following species are recommended for special study during the season: mustard (such varieties as are found in the vicinity), Canada thistle, purslane, lamb's quarter, pink-rooted pigweed, and quack grass. The pupils should be familiar with the general appearance of the plant; its appearance when coming up in the spring; whether annual, biennial, or perennial; nature of the root, and whether hard to pull up; if hard to eradicate, why so; its rate of growth compared with the garden plants; the number of seeds produced by a single plant; how the seeds are scattered.

THE APPLE TREE

(When the buds are beginning to open)

FIELD EXERCISE

The pupils, during an excursion that is conducted by the teacher or while making individual observations, obtain answers to problems of the following type:

What is the shape of the top of the apple tree?
Are all apple trees of the same shape?
What is the height of the trunk?
Measure the girth of the trunk of the largest?
Are the leaf buds and flower buds more numerous near the inside of the tree top or more numerous at the outer part of the top?

To the teacher.—When discussing the answers to the above problems, develop the conception of the convenience of the low stature of the tree for gathering the apples, of the wide-spreading branches for bearing a large crop, of the stoutness of the trunk for supporting the weight, and also of the position of the buds as adapting them for securing sunshine.

CLASS-ROOM LESSON ON THE APPLE TREE

Materials. — Twigs bearing flower and leaf buds. These are gathered by the pupils from the apple trees that were studied during the field exercises.

Each pupil finds on his twig the objects and markings, etc., as in the following outline:

Describe the shape of the twig.
Where were the apples that grew last year attached?
Describe the positions of the buds on the twigs.

Which buds are the larger, those at the end or those on the side of the twig?

Describe the condition of the bud scales.

Open the buds and find what they contain.

Of what use are the bud scales?

How many blossoms are in one bud?

Of what use to the young leaves is the downy covering?

FIELD EXERCISE FOLLOWING CLASS-ROOM LESSON

(Just after the blossoms are fully open)

What is the colour of the apple blossom?

Find the little green cup on which the petals rest?

Describe the cup.

Find the other things that are on the rim of, or that are within, the cup. What are they?

What insects visit the flowers?

Does the cup fall off when the petals fall?

Does the cup close up as soon as the petals fall?

What does the green cup grow to be?

To the teacher.—Apple trees have somewhat round or pyramid-shaped tops, varying in detail with the variety of apple tree. The twigs are short and usually crooked. The fruit twigs are called spurs. The buds at the ends of the twigs and spurs are the largest and contain both leaves and blossoms, and there are usually several blossoms in each bud. The bud scales burst apart and drop off as the leaves and blossoms develop. The side buds produce leaves only. The petals and pollen boxes are borne on the rim of the green cup, and inside the cup are found the five tips of the seed cases. When the petals drop off, the rim of the cup remains spread out for a short time. This is the proper time for spraying, so that the cup may hold a drop

of poison to kill the tiny worms which cause apples to be wormy. It is the green cup that grows and forms the flesh of the apple.

Orchard trees suitable for lessons for Form II are apple, plum, pear, peach, and cherry.

BIRD STUDY

A valuable exercise in bird study, suitable for the pupils of Form II, is the study of a pair of birds and the history of their home through the entire season.

A record, with dates, should be kept, and the following topics are suggested for observation:

Where the nest is located, protection of the nest, part of building done by each bird; eggs, number, colour, size, time required for hatching; young birds, number, description, how fed and upon what foods, time required before ready to leave the nest; history for a time after leaving the nest.

Birds suitable for study by the pupils of Form II are the crow, flicker, downy woodpecker, blue-bird, chipping-sparrow, phoebe, wren.

Correlate with art, by requiring drawings and models of the nest and its surroundings, and with language, by having pupils write the history of the nest and family.

THE TOAD

FIELD EXERCISES

Direct the pupils to watch for toads under the street lamps and on the lawns in the evenings, and to observe what they are doing.

Find out, by turning over boards, logs of wood, stones, and old stumps, where toads spend the daytime.

If there is a sandy beach near by, an interesting nature lesson is to trace a toad to its daytime retreat under a log or stone. Its wanderings and adventures during the night can be traced from the record that its trail makes in the sand.

Are toads that live in light-coloured sand of the same colour as those that live in black clay? Of what value to the toad are these differences in colour?

The pupils are thus led to see that although the toad is not a handsome animal, yet its rough, dark skin is of great value to it for concealment among the lumps of soil with which it harmonizes.

Can a dog be induced to seize a toad? Will he seize it as readily a second time as he did the first? The secretion from the glands of the toad have a biting, acid effect on the dog's mouth. This secretion will not injure a person's hands unless the skin is broken, and even then it does not "cause warts".

How many toads can you find on your lawn in one evening? How many in the vegetable garden? How many in the flower beds?

Place a toad on loose soil among some weeds and observe how it proceeds to get out of sight.

Is it true that a toad is attracted by music? Give reasons for your answer.

CLASS-ROOM LESSON

Secure a few living toads and keep them in a box covered with a pane of glass. Be sure to put moist soil and damp moss in the bottom of the box in which toads, frogs, newts, or snakes are kept. This enables these animals to live in comfort, and they soon become sufficiently accustomed to their surroundings to act in a normal way.

Observation.—By flicking in front of a toad a small feather or a bit of meat attached to a thread, the darting out of the tongue for catching prey on its adhesive surface may be observed.

The children, by bringing slugs, caterpillars, grubs, and various insects for the toads, may learn what composes the food of the animal. It is to be observed that the toad does not snap at an object until it moves.

DETAILED STUDY

Observation.—General shape; division into head, trunk, and limbs; size of head and mouth; position and structure of eyes and ears; difference in the size of the fore and hind limbs, and explanation of this difference by references to the use of the limbs; the hind foot, uses of the web; the glands on the surface of the body and their uses for protection.

Why is a large mouth useful? How are the ears fitted for life in water?

In conclusion, the teacher should make sure that the pupils appreciate the usefulness of the toad and also the beauty represented in its adaptations to its conditions of life. In these particulars the toad is a good illustration of the adage "Handsome is that handsome does".

LIFE HISTORY OF THE TOAD

In early spring look for the toads on the surface of the water in ponds. The music of the toads at this time of year has been described by one naturalist as "one of the sweetest sounds of nature".

The eggs may be found in these ponds at this time. They are attached to long strings of jelly which entwine

among grasses and other objects in the ponds. (Frogs' eggs are in masses of jelly, not in strings.) Place some of the eggs in a jar of water and set the jar in the window of the school-room. A great mass of eggs is too much to put in a jar, a few dozen eggs in a pint of water will be more likely to develop. The water in the jar should be changed twice a week.

Observations.—The light and dark areas of the eggs, the dark area gradually increasing in size; the increase in the length of the egg; the gradual change of the dark area into the general shape of a tadpole with head and tail, the first appearance of the gills, the separation from the jelly, the movement by means of the tail, the disappearance of the gills, the growth of the hind legs and, later, of the forelegs, and the disappearance of the tail.

Questions and Observations.—What is the use of the dark colour of the area from which the tadpole is formed?

Explain the uses of the strings of jelly.

Describe how the tadpole swims.

Upon what does the young tadpole feed?

What is the advantage of external gills at this stage in the tadpole's life?

Later Observations.—The disappearance of the gills, the budding out of the hind legs and, later, the forelegs. While the legs are growing out, the tail gradually becomes smaller, at the same time the shape changes to that of the adult toad with a broad body and large mouth and eyes.

Questions.—What movements has the toad which the tadpole did not have?

What makes these movements possible?

Why is the mouth of the toad better suited to its manner of life than the small mouth of the tadpole would be?

Of what advantage to the tadpole was the smooth outline of its body, and why is the rougher outline of the toad's body better suited for the life of the latter?

Why would gills be unsuitable for the life of the toad?

To the teacher.—From the dark area of the egg the tadpole develops, the dark colour absorbs the sunlight, and this causes growth. The jelly holds the eggs up so that the sun can reach them and it also keeps them from being swept away by the water. The tadpole is very small, and external gills are needed to keep it in very close contact with the water. The tail does not drop off, the substance in it is absorbed into the body of the growing toad to serve as nutriment.

Since all the changes in the development of the toad from egg to adult form take place in about one month, this comparatively rapid development makes the life history of the toad particularly suitable for observation work.

The development of the eggs of the frog or newt may be studied from preparations made in precisely the same way as those for the study of the development of the toad.

If observations on the developments of two forms are carried on at one time, interesting comparisons can be made on such points as, shape and size of the eggs, time required for development, shapes and colours of the tadpoles, activity of the tadpoles, etc.

THE EARTHWORM

Time.—May or June, in connection with gardening, when the working of the worms in the moist soil of the garden is quite noticeable.

Outdoor studies may be assigned, as:

Observe the loose soil at the entrance to the burrows. Insert a straw in the burrow and, following it, dig downward with a garden trowel and learn the nature of the earthworm's home.

Are earthworms ever found out of their burrows during the day? If so, on what kind of days? Why do earthworms burrow deep in dry weather?

Earthworms can breathe only when the surfaces of their bodies are in moist conditions.

Go out at night with a lantern to where earthworms are known to have burrows, observe the worms stretched out with the rear ends of their bodies attached to the burrows, and note how quickly they draw back when they are touched. Do they draw back if the ground is jarred near them? Do they draw back when the light falls upon them?

State the facts which are taught by the observations which were made on the above topics.

CLASS-ROOM LESSON

Put two or three earthworms into a jar of rich, damp soil, on top of which there is a layer of sand a quarter of an inch thick. Put bits of cabbage, onion, grass, and other plants on the surface and cover the jar with a glass slip or cardboard.

After a few days, examine the jar, noting the number of burrows, the foods selected, the castings, the food dragged into the burrows. Pour water into the jar and observe the actions of the worms. Can an earthworm live in water?

Place an earthworm on a moist plate or board and direct the pupils to study it, as follows:

Distinguish the head from the rear end, the upper from the lower surface. Observe the means of living. To assist in the latter observation, stroke the worm from rear to head and find the four double rows of bristles. Why is it difficult to pull an earthworm out of its burrow?

Find the mouth. Has the earthworm any eyes, ears, or nose? Place a pin in the path of a moving worm and try to explain why it turns aside before touching the obstacle. Test the sensitiveness to feeling. Why is it cruel to put an earthworm on a fishhook?

From the soil castings found in the jar, infer the value of earthworms for enriching and pulverizing soil. (See "Soil Studies", p. 269.)

REFERENCES

Bailey and Coleman: *First Course in Biology.* Macmillan Co. $1.25.

Crawford: *Guide to Nature Study.* The Copp, Clark Co. 90 cents.

Kellogg: *Elementary Zoology.* Holt & Co. $1.35.

THE AQUARIUM

A large glass aquarium may be purchased from any School Supply Company at a cost of a few dollars, but a small globe-shaped aquarium such as is used for goldfishes will be found suitable for school purposes. If it is not possible to secure either of these, a large glass jar, such as a battery jar or large fruit jar, will be found to answer quite well.

To set up the aquarium, put into the jar about two inches of clean shore sand (sand from a sand pit, washed until the water comes away clear, will do). Secure from a pond some water-plants, place these in the jar with their roots covered with sand and secured in position by small stones. Pour in water until the jar is nearly full, taking

care not to wash the roots out of place, and then put in a freshwater clam and a few water snails. These are scavengers, for the clam feeds upon organisms that float in the water, while the snails eat the green scum that grows on the glass.

The other aquarium specimens may now be put in. One fish about three inches long to a gallon of water is about the right proportion. When there is a sufficient quantity of plant life to keep the water properly oxygenated and enough animal life to supply the carbon dioxide necessary to keep the plants growing well, the aquarium is said to be *balanced.*

The balanced aquarium does not require that the water be changed more often than once in two months.

Too much direct sunlight causes too rapid growth of green slime, hence the aquarium should not be set in a window. Close to a window through which the sun shines upon it for an hour or longer each day is the best position.

Do not supply more food to the animals in the aquarium than they can eat up clean.

Crayfish, perch, trout, and other freshwater fishes are destructive of insect larvæ and other aquarium specimens, hence care must be taken in selecting the specimens that are put together into an aquarium.

Suitable animals for the aquarium: mosquito larvæ, dragon-fly larvæ, caddice-fly larvæ, crayfish, clam, water snails, tadpoles, fish, frog, turtle.

AQUARIUM SPECIMENS

MOSQUITO

Time.—May or June.

Questions and Observations.—At what time of the year are mosquitoes most plentiful? In what localities

are they most plentiful? Why are they most plentiful in these places? Are mosquitoes ever seen during fall or winter? How do you account for their rapid increase in number early in summer?

How do mosquitoes find their victims? Observe the humming noise and try to discover how it is made.

Watch a mosquito as it draws blood from your hand. Does the point of the beak pierce the skin?

Capture a number of mosquitoes and place them in a jar containing some water and a few straws or sticks standing upright out of the water. Cover the mouth of the jar with a glass plate or fine gauze. Watch for the rafts of mosquitoes' eggs on the surface of the water.

The eggs may also be found on the surface of ponds or open rain barrels, and may be transferred to water in a jar in the laboratory.

STUDY OF THE ADULT FORM

Note the shape, colour, sucking tube, wings, and legs. Compare with the house-fly.

Distinguish the male insect from the female; the former has feathery feelers, and has mouth parts unsuited for biting.

How many kinds of mosquitoes have you seen? Direct attention to the kind which causes the spread of malaria. It is recognized by its habit of standing with its body pointing at right angles to the surface on which its feet are placed or, in other words, it appears to stand on its head.

THE DEVELOPMENT

Describe the egg raft.

Observe the wigglers (hatched in about a day); the

divisions of the body of the wigglers; position of the wigglers when at rest. Observe that the tail end is upward. Lead the pupils to perceive that this is the means of getting air.

Observe the rapid movement toward the bottom when disturbed; the means of causing this movement; the change into the large-headed pupæ—a change which takes place about ten days after hatching; the almost motionless character of the pupæ; the change from the pupæ forms into the adult—a change which takes place at about the fourth day of pupæ life.

Put some mosquito larvæ (wigglers) into the fish aquarium. Are mosquitoes of any use? The wigglers are the food on which some young fishes live. Young bass and trout feed upon them.

Put some kerosene on the surface of a jar in which there are mosquito larvæ. Describe a method of destroying mosquitoes.

The teacher tells about the mosquito as the cause of the spread of malaria. From the fact that the eggs hatch on stagnant water, deduce a benefit arising from the draining of land.

REFERENCES

Silcox and Stevenson: *Modern Nature Study*
Hodge: *Nature Study and Life*

CADDICE-FLY

Time: May.

The caddice-flies are very interesting insects, owing to the habits of the larvæ of building little cases of wood, stones, or shells, in which they pass their development stages under water.

These larvæ are easily found during the month of May in little streams of water everywhere throughout the Province. Look for what at first sight appears to be a bit of twig or a cylinder of stone about an inch long moving along the bottom as though carried by currents. Closer observation will result in the discovery that this is a little case composed of grains, of bits of stick, or of sand and tiny shells, and the head of the occupant may be seen projecting from one end.

Collect some of these larvæ in a jar of water and transfer them to the aquarium. Direct the pupils to look for others in the streams, so that they may observe their appearances and movements in their natural environment. If kept in jars, the water must be changed every day, and the top should be covered to prevent the escape of the adults.

Observe.—The shape of the various kinds of cases; the materials, and how fastened together (chiefly by silk); the part of the larva that protrudes from the case; the movement, and how caused; the fitness of the case as a protection. Note hardness, colour, and shape as protective features.

The pupils will be fortunate if they observe the sudden rise of the larva to the surface of the water and the almost instantaneous change into the four-winged fly.

INSECTS SUITABLE FOR LESSONS IN FORM II

Walking-stick insect, katydid, cricket, mole-cricket, clothes-moth, giant water-bug, potato beetle, click-beetle, luna moth, and swallow-tail butterfly.

CHAPTER IX

FORM III

AUTUMN

GARDEN WORK

The pupils in this Form should be able to do all of the work required of them in the garden without assistance. They should aim at intensive and thorough cultivation and, in the autumn, when the plants of their gardens ripen, these should be removed and the soil carefully spaded. They should continue the work of selecting the seed from the best flowers, as indicated in the work for Form II, and should grow some seed from vegetables and perennials seen to be particularly good.

Boys in this Form may also wish to do some gardening for profit. In some cases where there is plenty of space, this may be carried on in a part of the school garden set aside for that purpose. Usually, however, it will be found most convenient to carry it on in the home garden. Best varieties for local markets should then be grown and attention given to the proper time and manner of marketing or storing for a later market. Cool, well-ventilated cellars are best for most fruits and vegetables.

TREATMENT OF FUNGI

During the summer and early autumn months attention should be given to the spraying of plants for blight and for injurious insects. The potato is commonly affected by a fungous disease which causes the stalks to blacken

and die before the tubers have matured. This disease may be prevented in large measure by the use of a fungicide known as Bordeaux mixture. This may be prepared as follows:

Take one pound of copper sulphate (blue vitriol); make it fine by pounding it in a bag or cloth and then dissolve it in water, using a wooden pail. It dissolves rapidly if put in a little cheese-cloth sack, which is suspended near the top of the pail by putting a stick across the pail and tying the sack of copper sulphate to it. Dilute this solution to five gallons. Take also a pound of unslaked or quick-lime and add a cupful of water to it. When it begins to swell up and get hot, add more water slowly, and, when the action ceases, dilute to five gallons. Mix these two solutions together in a tub or barrel, and churn them up, or stir them together vigorously. They give a deep robin's-egg-blue mixture, which is slightly alkaline and should be used at once. The solutions can be kept separate as stock solutions throughout the summer and then diluted and mixed whenever needed. Care should be observed in not mixing the solutions before each has been diluted to the strength, one pound to five gallons. A piece of blue litmus paper will be convenient to prove that the mixture is alkaline. If alkaline, as it should be, the paper remains blue when dipped in it. If the mixture turns the litmus paper red, it must have more lime-water added to make it alkaline. The potato tops should be thoroughly sprayed with this mixture when about ten inches high and then once every two weeks, until they have been treated three or four times. This is to prevent blight and not to kill bugs. If the potato-beetle is troubling the potatoes, add paris-green to the Bordeaux mixture—a teaspoonful to every two gallons. To prove the value of this

treatment have a trial plot of potatoes which receive all attention save spraying with Bordeaux mixture. If a heavy rain should follow the spraying, it should be repeated.

Potato-scab may be prevented to a large degree by soaking the tubers before cutting for planting in a solution of formalin (a 40-per cent. solution of formaldehyde) one-half pint to fifteen gallons of water. Seed grain is frequently treated this way before sowing, to destroy smut spores. A pound of formalin is put in forty gallons of water in a large barrel. A bag full of the grain to be treated is set in the barrel of formalin mixture for about two hours and then taken and dried on a floor that has been previously washed with water containing formalin. A solution of copper sulphate (bluestone), one pound in twenty gallons of water is sometimes used. The grain is left in this solution for twelve hours and then dried for sowing. All bags and utensils should also be disinfected with this formalin solution.

TREATMENT OF INSECTS

In order to poison insects successfully, it is necessary to determine how the insect feeds. If it is a biting insect, that is one that eats the leaf, such as the potato beetle, paris-green should be used. Paris-green sometimes burns the tender leaves. This may be prevented by adding a tablespoonful of lime to each pail of water used. It may also be used dry with flour or dust.

If the insect feeds by sucking the juices from the leaf, as is the case with plant-lice, then a solution that kills by contact must be used, such as whale-oil soap, one ounce to a quart of water. Tobacco-water is sometimes mixed with the soap solution as follows:

Four pounds of tobacco-waste is steeped in nine gallons of hot water for five hours; this is then strained, and to the tobacco-water one pound of whale-oil soap dissolved in one gallon of hot water is added and mixed thoroughly.

Kerosene emulsion, which is made as follows, is very destructive to plant-lice and scale insects:

Dissolve a quarter of a pound of common laundry soap in half a gallon of rain-water and, while hot, mix with one gallon of coal-oil and churn vigorously for five minutes to get a smooth, creamy mixture. On cooling, it thickens and is diluted before using by adding nine quarts of warm water to one quart of the emulsion. Use smaller quantities in correct proportions when only a few plants are to be treated.

CABBAGE-WORM

The larvæ of the cabbage-butterfly sometimes do a great deal of harm by eating the cabbage leaves. It will not do to use paris-green on cabbage, as the leaves are for eating. Instead, use pyrethrum or insect powder, which may be diluted by mixing with cheap flour—one ounce of insect powder to five of flour. Mix thoroughly and leave in a closed tin over night. Dust the mixture on the leaves from a cheese-cloth bag by tapping with a small stick or from a dusting-pan. If used while the dew is on the leaves, it sticks better. Insect powder is not poisonous to man as is paris-green, and so may be used freely on cabbage or other similar plants.

PLANTS

ANNUALS, BIENNIALS, AND PERENNIALS

CLASS-ROOM LESSON

By means of questions based upon the pupils' knowledge of a few common annuals, such as the oat, sweet-pea, and garden aster, develop the following points:

1. These plants are always grown from seeds.

2. These plants produce flowers and ripe seeds during one season's growth.

3. These plants wither and die in the autumn.

Plants having these characteristics are called *annuals.* The teacher explains the meaning of the word and requires the pupils to name a few other annuals.

In a similar way, discuss a few common types of *biennials,* such as turnip, cabbage, hollyhock, and develop the following points:

1. These plants produce no flowers and seeds during the first year of their life.

2. These plants, during the first year, lay up a store of food in roots, leaves, or stems.

3. The food is used in the second year of the plant's life to nourish the flowers and seeds.

A biennial should be grown for two years in the school garden to furnish material for concrete study.

In a similar way discuss a few common types of *perennials,* such as rhubarb, dahlia, apple tree, and develop the following points:

1. These plants may or may not produce seeds during the first year's growth.

2. Some of these plants are herbs, but most of them are trees and shrubs.

3. Food is stored in roots or stems to provide for early spring growth.

4. These plants live on from year to year.

GARDEN STUDIES

ANNUALS

Observations.—Some plants, such as poppy and candytuft, are early blooming, while others, such as aster and cosmos, bloom in late summer, hence a selection should be made that will yield a succession of bloom throughout the season.

Some are hardy annuals which can be grown from open planting, even when the weather is cold. These often seed themselves; for example, sweet-pea, morning-glory, phlox, poppy, sweet-alyssum.

Some are half-hardy annuals, such as asters, balsams, stocks, and nasturtiums. These must be started indoors or in hotbeds, or if in plots, not until the soil is quite warm.

The heights of annuals vary, and consequently they must be arranged in the bed in such a way that tall plants will not shade the short ones.

BIENNIALS

Observations.—During the first year food is stored in the root of the turnip, carrot, parsnip, and beet, in the leaves of the cabbage, and in the stem of the hollyhock.

Flowers and seeds are produced during the second year, and the storehouse becomes empty, dry, and woody. Pre-

paration for winter is therefore, in the case of biennials, preparation for a renewal of growth the following spring.

PERENNIALS

Observations.—The highest forms of plant life are found in this class; namely, the strong, large, hardy trees and shrubs.

The herbaceous perennials are equipped with underground parts that act as storehouses of food to ensure the growth of the plant through successive seasons. Examples: the roots of dahlia, rhubarb, dandelion, and chicory; the underground stems of potato, onion, tulip, scutch-grass, Canada thistle, etc.

Many of the wild flowers that bloom in early spring belong to this class, and their rapid growth then is made possible by the store of food in the underground parts. Examples: trillium, bloodroot, squirrel-corn, Indian turnip, Solomon's seal, etc.

SPECIAL STUDY OF GARDEN PLANTS

A few plants should be selected for special study, and the following are recommended: annuals—sweet-pea, pumpkin, and corn; biennials—cabbage, parsnip, and carrot; perennials—dahlia, rhubarb, and couch-grass.

It is desirable that the observations be made upon the plants in the garden, but they may be conducted in the class-room upon specimens brought into the room by the pupils.

SWEET-PEA

Examine the stem of the sweet-pea and describe its form, its uniform slender structure, and the fact that it

climbs. Find out just how it climbs. The pupils will observe the tendrils, which are extensions of the midribs of the leaves.

Describe the leaves, noting what is meant by calling them *compound.*

Observe the position of the flower, its colours, odour, size, and form. What insect does it resemble in shape? What different features of the flower enable it to attract attention?

The names and uses of the floral organs may be taught to this class. For example:

> Pupils find the green blanket that protects the bud. This is the *calyx.*
>
> The beautiful, attractive part is the *corolla.*
>
> The parts that produce the pollen are called *stamens.*
>
> The case that holds the seeds is the *pistil.*

Examine flowers of different ages and trace the change from the minute pistil to the pod.

Study, comparatively, the flowers of the field-pea, bean, or wild vetch.

Select a few of the finest blossoms of the sweet-pea and put tags on them while they are still in bloom. When they ripen, collect the seeds and preserve them for spring planting.

Conduct observation lessons on the pumpkin and corn, in which the pupils will discover such facts as those given below.

PUMPKIN

Notice the method of growth—the stem no stronger than that of the sweet-pea, but lying flat on the ground. Notice the little roots sent out here and there where the

stem touches the ground. This gives extra nourishment. The leaves are not numerous and grow only in one direction, but are very large—entirely too large to be borne upon an upright stem. Notice the large funnel-like flowers and that not all of them set fruit. Examine the flowers. Some of them have stamens for producing pollen, but no pistil. These never produce fruit, for pumpkins are simply enlarged and ripened pistils. Look for insects and examine them to find out whether they are carrying pollen. Notice younger pumpkins and even blossoms toward the end of the vine. Pick all the blossoms and small pumpkins off a vine, leaving only one of the best growing pumpkins. See whether this one grows larger than one of equal age on a vine having young pumpkins developing on it. Notice the arrangement of the seeds inside a ripe pumpkin. Collect some seeds, wash clean, and dry for spring planting. It is desirable to plant pumpkins late in May, so that they will have flowers on their vines as late as September.

Study the flowers of the cucumber and compare them with those of the pumpkin.

CORN

This plant is native to America, was greatly prized by the aborigines, and even worshipped by some of them. Note the upright character of the plant and how the stalk is divided into sections by the joints, or nodes. Count these joints and also the leaves, and note the relationship of leaves and joints in the stalk, and how the leaves come off in different directions so as not to shade each other. Note the strong, stringy threads in the leaf, which give strength to the leaf as well as circulation of sap. They are strong and elastic, allowing of movement. The same strengthen-

ing fibres are seen in the stalk when it is broken across. In the stalk these fibres are arranged in a tubular form, as this gives greatest strength, the centre being soft and weak. The stalks are largest near the base, where the greatest stiffness is required. The nodes are also closer together here for strength. The stem is made much stronger by the bases of the leaves being wrapped so firmly around for a distance above the point of attachment at the node. Notice the close-fitting sheath or rain-guard, where the blade of the leaf leaves the stalk. This prevents rain soaking down inside the leaf sheath, but lets it run down the outside to the root where it is needed. As the plant gets older and taller, new roots come out from the node next above the root and sometimes from the second node above. These prop-roots are needed for support as the stalk lengthens, and they also reinforce the feeding capacity.

Note the appearance of little cobs in the axils of the leaves. As soon as the silk appears, take a cob off and open it carefully. The little cob, which corresponds to the pistil in other plants, is covered with small and undeveloped kernels, and to each kernel one of the strands of so-called silk is attached. Whilst this little cob is forming, a bunch, or tassel, of flowers is forming on the top of the corn plant. Open one of these flowers and find the stamens with pollen-grains inside. This pollen, when shed, falls upon the silk, and each grain sends a tiny tube down inside the silk to the delicate ovules on the cob, fertilizing them and starting them to develop. The silk then withers. The wind carries this pollen.

Find out how the silk is fitted for catching the pollen. What is the need for the great quantity of pollen that the plant produces?

Strip off the husks and compare the tough, hard husks that are found on the outside with the soft paper-like husks found close to the cob. Show how each kind is fitted for its particular work.

Pupils make experiments in the corn plot to find:

1. Whether the corn grows faster:
   (1) When the soil is kept mellow or when the soil is hard;
   (2) When the days are warm or when they are cool;
   (3) When the nights are cool or when they are warm.
2. The effect of growing black corn and golden corn in the same or in adjoining plots. Account for the result.

CORRELATIONS

Art: Clay-modelling and drawing exercises on the whole plant, and also upon the ear.

Literature: Interpretation and reading of "Blessing the Corn-fields", from *Hiawatha*.

History: The name Indian corn originated in the early colonial days of the Eastern and Central States, when the pioneers obtained corn from the Indians. The Indians showed the settlers how to kill the trees by girdling and how to plant the corn among the standing trunks, and thus have corn ready for roasting by August, and for grinding into meal or for boiling to make hominy by September.

SEED DISPERSAL

The lessons on seed dispersal which were begun in Form I should be continued in this Form.

I. LESSON

Select a few weeds belonging to species which produce large numbers of seeds, such as wild mustard, white cockle, false-flax, etc. Distribute the seed pods among the pupils of the class and require them to estimate the number of seeds produced by each plant.

By references to observations made in the garden, help the pupils to recall the bad results, both to parent plants and to young seedlings, of improper scattering of seeds, namely:

1. The excessive crowding and shading, which causes the plants to become weak.

2. Insufficient food and moisture for the large number of plants, which causes the plants to be small and worthless.

Discuss how the crowding of cultivated plants is prevented and, in a general way, how nature provides for the scattering of seeds.

The great work of the plant is the production and dispersal of its seeds.

Ask the pupils to be on the alert to find examples of plants in which provision is made for the dispersal of the seeds, and to bring these plants to the class for the next lesson.

DETAILED STUDY OF SEED DISPERSAL

II. CLASS-ROOM LESSON

Make use of the specimens gathered by the pupils and by the teacher for observing and classifying as follows:

1. Seeds that steal rides. Examples—burdock, blue burr, pitch-fork weed, barley, stick-tight, hound's tongue.

2. Seeds that are carried in edible fruits which have attractive colours, tastes, etc. Examples—apple, grape, cherry, rowan, hawthorn.

3. Seeds that are carried by the wind. Examples—dandelion, thistle, milkweed, maple, pine, elm.

4. Seeds that are scattered by being shot from bursting pods. Examples—violet, jewel-weed (touch-me-not), sweet-pea, witch-hazel.

5. Seeds that are scattered by plants which are rolled along by the wind. Examples—Russian thistle, tumble-mustard, tumble-grass.

6. Seeds that float. Very many seeds float, although not specially fitted for floating, and some, such as the cocoa-nut and water-lily, are especially adapted for dispersal by water.

To the teacher.—Require the pupils to observe the special structure that facilitates the dispersal of the seed. As an illustration, ask the pupils to find the seeds of the burdock and to describe what the burr is really like. They find that the burr is a little basket filled with seeds. The basket has many little hooks which catch on the hair of animals and, since these hooks turn inwards, they serve to hold the basket in such a position that all the seeds are not likely to drop out at one time. The pupils should also observe that these baskets are quite firmly attached to the parent plant until the seeds are ripe; after that the baskets break off the plant at the slightest pull.

SEED COLLECTIONS

During late summer and in the autumn the seeds of the weeds that have been identified by the pupils should be collected.

Instruct the pupils to rub the ripened seed pods between the hands until the seeds are thrashed out, at the same time blowing away the chaff. The seeds are now placed in small phials or in small envelopes and these are carefully labelled. If possible, fill each phial so that there may be sufficient seed for use by all the members of the class in the lessons on seed description and identification which are to be taken during the winter months, when Nature Study material is less plentiful than it is in the summer and autumn. The phials or envelopes may be stored in a shallow box, or the phials may be mounted on a stout card. They may be attached to this card either by stout thread sewed through the card and passing around the phial, or by brass cleats, which may be obtained with the phials from dealers in Nature Study supplies.

MAN AS A DISPERSER OF SEEDS

Man as an agent in the dispersal of seeds should be made a topic for discussion.

Obtain, through the pupils, samples of seed-grain, clover seed, timothy seed, turnip seed, etc. Ask the pupils to examine these and count the number of weed seeds found in each.

The results will reveal a very common way in which the seeds of noxious weeds are introduced.

Describe the introduction from Europe to the wheat-fields of the Prairie Provinces of such weeds as Russian thistle, false-flax, French-weed. The seeds of these weeds were carried in seed-grain, fodder for animals, and also in the hay and straw used by the immigrants as packing for their household goods.

Careful farmers will not allow thrashing-machines, seed drills, fanning-mills, etc., to come from farms in-

fested with noxious weeds to do work upon their farms, nor will they buy manure, straw, or hay that was produced on dirty farms.

THE SUGAR MAPLE

FIELD EXERCISES

Select a convenient sugar maple as a type. Ask the pupils to observe and to describe the height of the tree, the height of the trunk below the branches, the shape and size of the crown, the diameter of the trunk, the colour of the bark, the markings on the bark, the number and direction of the branches, and the density of the foliage. Compare the density of the foliage with that of other kinds of trees. Require the pupils to make a crayon drawing of the tree.

Examine the crop of grain produced near a shade tree. Compare the crop on the north side of the tree with that on the south side. Account for the difference.

Is the crop around the tree inferior to that in the rest of the field?

Find out how long the various sugar maple shade trees in the locality have been planted. Is it a tree of rapid or slow growth? Are these sugar maples infested with insects or attacked by fungi?

Do these trees yield sap that is suitable for making maple syrup?

Examine trees that have been tapped and find whether the old wounds become overgrown or cause decay.

Find out all you can about the uses that are made of maple wood.

To the teacher.—The sugar maple is the most highly prized of our native trees for ornament and shade. It

grows fairly rapidly and becomes a goodly-sized tree within twenty years after it is planted. The symmetrical dome-shaped crown and the dense foliage of restful dark green give to it a fine appearance. It is hardy and has few insect pests, and its value is enhanced by the abundant yield of rich sap.

As a commercial tree it has few superiors; the wood is hard and durable and takes a high polish. It is used for flooring, furniture, boat building, for the wooden parts of machinery and tools, and for making shoe-pegs and shoe lasts. As fuel maple wood is surpassed only by hickory.

MAPLE LEAVES

CLASS-ROOM LESSON

The pupils bring to the class leaves of the sugar maple. Each pupil is provided with a leaf and makes direct observations under the guidance of the teacher.

Observations.—Colour, dark green on the upper surface, lighter green on the lower surface. Surface smooth and shiny.

Shape: star-shaped, broader than long.

Lobes: usually five, often three; each lobe has usually two large teeth.

Base has a heart-shaped notch; petiole long and slender, usually red.

Veins are stiff and run out to the points of the teeth.

Distribute leaves of the *red* maple and ask the pupils to note the general resemblance. Next ask them to compare the leaves as to shape, texture, and teeth on the margin.

Ask the pupils to find red maple trees and also to find maples with leaves that are different from those of the red maple and those of the sugar maple.

Make a collection of maple leaves when they are in autumn colours. (See Collections, page 33, in General Method.)

To the teacher.—The leaves of the red maple are longer than broad, and are not so smooth and shiny as the leaves of the sugar maple. There are numerous "saw teeth" on the margins of the lobes. The silver maple, with leaves having silver-white under surfaces, is another common species.

A lesson similar to that on leaf studies may be based on the fruits (keys) of the maples.

The oak, ash, elm, beech, or birch may be taken up in lessons similar to those outlined for the study of the maple.

CORRELATIONS

With literature and reading: By interpreting "The Maple", *The Ontario Readers, Third Book,* page 179;

With art: By sketching the tree and reproducing the autumn leaves in colour work.

WEED STUDIES

In every locality there are about a dozen weeds that are particularly troublesome, and the pupils of Form III should be taught to identify these and to understand the characteristics which make each weed persistent.

To produce these results it will be necessary to have exercises such as the following:

1. The teacher exhibits a weed to the pupils and directs their attention to a few of the outstanding features of the plant.

2. The pupils are required, as a field exercise, to observe where the weed is abundant; and whether in hay field, pasture, hoe crop, or in grain. The pupils will bring specimens to the class.

3. Detailed study in the class of specimens of the weed brought by the pupils to find offensive odours and prickles, also the character of the leaves, flowers, seed pods, and seeds, including the means of dispersal; the underground parts, whether underground stem, tap-root, or fibrous root, and the value of the underground parts as a means of persistence.

4. The pupils make a collection of the weeds that have been studied. (See Plant Collection, page 39, in General Method.)

5. The pupils make collections of the seeds of the weeds that have been studied.

OBSERVATION LESSON ON WEED SEEDS

The seed of a weed should always be exhibited and studied in association with a fresh or a mounted specimen of the weed.

Each pupil should use a hand lens in examining the seed.

The pupils examine the seed of each species and describe it according to the following scheme:

NAME OF SEED

Colour: .....

Size: (in fractions of an inch) .....

Shape: .....

Details: .....

Occurrence: .....

The results of the pupils' study of the ox-eye daisy would then appear in the following form:

SEED OF OX-EYE DAISY

Colour: Black and greenish-white in stripes,

Size: One sixteenth of an inch,

Shape: Club-shaped,

Details: Grooved lengthwise, yellow peg in large end,

Occurrence: A common impurity in grass seed.

GRASSHOPPER

(Consult the Manual on *Suggestions for Teachers of Science*: Zoology, First year.)

The ease with which this insect may be obtained in August or September, together with its fairly large size, makes it a suitable specimen for insect study. It is also a typical insect, so that a careful study serves as a basis for a knowledge of the class *insecta*.

FIELD EXERCISES

Problems to be assigned for outdoor observation: Locomotion by flying, leaping, walking; protective coloration and habit of "lying low"; its behaviour when caught; in what kinds of fields it is most plentiful; in what kinds of weather it is most active; its position on the grass or grain when feeding; the nature and extent of the damage done by it.

Use a class period for discussion of the above. Confirm, correct, or incite to more careful observation.

CLASS-ROOM LESSON

(Studied as a typical insect)

Observations.—The three divisions of the body—head, thorax, abdomen; the segmental division of the two latter parts; the hard, protecting covering; the movements of the abdomen; the two large compound eyes and three small eyes; the feelers; the two pairs of mouth feelers; the cutting mandibles; the three pairs of legs (one pair for leaping) and two pairs of wings on the thorax; the breathing pores, the ears, ovipositors of the female.

The young grasshoppers may be found in spring or early summer, and a few even in late summer, among the grass of old meadows and pastures. They are easily recognized because of their general resemblance to the adult and are in the stage of development called the *nymph* phase. Note the hairy body and the absence of wings.

To the teacher.—The moulting of the nymph is a very interesting process to observe and so is the laying of the eggs by the female in a burrow that she prepares in the soil. If females secured in July are kept in a jar having two inches of soil in the bottom, they will lay their eggs in the soil; the nests and eggs may then be taken up and examined.

In order that we may not destroy our friends and helpers, it is expedient to know what creatures help to hold pests in check.

The enemies of grasshoppers are birds and insect parasites. Under the wings of grasshoppers may frequently be found little red mites; these kill the grasshoppers to which they are attached. The blister-beetles lay their eggs in the grasshoppers' nests, and the larvæ of the beetles feed upon and destroy the eggs.

The birds that are especially useful in destroying grasshoppers are the meadow-lark, crow, bobolink, quail, grasshopper sparrow.

The curious hairlike worms known to the school boys as "hair snakes" because of the belief that they are parts of horse hairs turned into snakes, are worms that pass the early part of their life within the bodies of grasshoppers and, when the insects die, the worms escape and are washed by rains into troughs and ponds where their movements attract attention.

Study the cricket and house-fly and compare the cricket with the grasshopper.

APHIDES

In September obtain leaves of sweet-pea, apple, rose bush, maple, oak, turnip, etc., on which the insects are feeding; also provide specimens of woolly aphides on the bark of apple trees or stems of goldenrod or alder.

Observe the nature of the injury to the leaves and plants on which these insects feed.

Do the insects bite the leaves or suck the juices? Give evidence in support of your answer.

Sprinkle paris-green on the leaves; does this kill the insects? Why does it not? Spray the insects with a little oil, such as kerosene, or with water in which the stub of a cigar has been soaked; what is the effect?

Insects that suck juices from inside the leaf escape the poisoning from solutions in the leaf surfaces; such insects are killed by oils which enter the breathing pores and cause poisoning.

Search in the garden, orchard, and forest for plants attacked by aphides. Carefully observe the lady-birds that are frequently found where there are aphides. Lady-birds

(also called lady-bugs), are small, spotted beetles, broad oval in form, of bright colours, red and black, or yellow and black, or black and white.

They are of great service to the farmer and gardener because their foods consists largely of plant-lice (aphides).

Watch the action of ants which are found among the aphides. The ants may be observed stroking the aphides with their feelers, causing the aphides to excrete a sweet fluid on which the ant feeds. Aphides are sometimes called ant-cows.

Direct the attention of the pupils to the difference between the male and female aphides; the males have wings, but the females are wingless.

TOMATO WORM

THE ADULT

The adult moth may be captured on spring evenings when the lilacs are in bloom, as it buzzes about among the lilac blossoms sucking their honey. It is frequently mistaken for the humming-bird when thus engaged. It may also be observed during the summer evenings laying its eggs on the leaves of tomato vines.

Observe the worms that hatch from these eggs and note their rapid growth. Keep the larvæ in a box in the school-room and feed them on tomato leaves. Note their size and colour, the oblique stripes on the sides, the horn which is used for terrifying assailants, the habit of remaining rigid for hours—hence the name sphinx moth.

The larvæ burrow into the ground in September to form the chrysalides, hence there should be soil in the vivarium in which they are kept.

THE CHRYSALIS

Observations.—The shape, colour, nature of the covering, the long handle, the wing impressions, the segmental part, the emergence of the adult in May or early June.

What organ of the insect was contained in the "handle" of the chrysalis?

The adult is one of the handsomest of moths, because of its graceful, clear-cut shape and the variegated grays and yellows of its dress. Look on poplar, cotton-wood, plum, and pine trees, and on tobacco plants for relatives of the tomato worm, the large green larvæ whose chrysalis and adult forms resemble those of the tomato worm.

THE CROW

Crows are so plentiful that there will be no difficulty in making observations on the living birds in the free state in spring or summer. (As the crow is a bird that is easily tamed, it may be possible to have a tame crow in the class-room for more careful study of the details of structure.)

Observations.—Describe its attitude when perched, movements of the wings in flight, speed of flight. Why does the crow perch high up in trees? What gives to the crow its swift flight?

Study the various calls of the crow and note the alarm, threat, summons, and expression of fear.

Find the nest and note its position, size, build, materials, eggs, and young. How is the nest concealed? What makes it strong?

Are crows often seen on the ground? Do they walk or hop?

Observe and report on the crow's habits of feeding. It eats corn, potatoes, oats, beetles, crickets, grasshoppers, cutworms, and occasionally birds' eggs or young birds.

Why do king-birds chase and thrash the crow? Are scarecrows effective in keeping crows off the grain fields?

Note the sentinels that are on the watch to warn other crows of danger.

Give reasons for the belief that the crow is a wise bird.

Give reasons for regarding the crow as a neighbour of doubtful character. Give reasons why crows should be protected.

NOTE.—Crows will not pull up corn and seed that has been covered with coal-tar before it is planted.

In addition to the animals already named, the musk-rat, raccoon, fox, flying-squirrel, robin, wren, and king-bird will be found convenient for study in many localities.

The swimming of the musk-rat, and how its shape, fur, feet, and tail fit it for a life in water are topics suitable for observational exercises, as are also its food, its winter home, and the burrows leading from the water into the banks. In the case of the winter home, the location, the structure, the submerged entrance, the living-room, and the surrounding moat, are topics of interest.

CORRELATIONS

With literature: By reading animal stories, such as, *The Kindred of the Wild* and "Red Fox," by Charles G. D. Roberts; and *Wild Animals I Have Known*, by Ernest Thompson-Seton.

With language: By oral and written descriptions of the animals that have been observed.

CHAPTER X

FORM III

WINTER

CARE OF PLANTS IN THE HOME

THE CARE of flowering bulbs which was begun in Form I will be continued in Form II. The growing of new plants from cuttings will now be taken up. In those schools which are kept continuously heated, potted plants may be kept throughout the year. The pupils will come to appreciate the plant's needs and learn how to meet them in the supply of good soil, water, and sunlight. The following points should be observed:

1. Good potting soil can be made by building up alternating layers of sods and stable manure and allowing this compost to stand until thoroughly rotted. A little sharp sand mixed with this forms an excellent soil for most house plants.

2. Thorough watering twice a week is better than adding a little water every day.

3. The leaves should be showered with water once a week to cleanse them from dust.

4. An ounce of whale-oil soap dissolved in a quart of water may be used to destroy plant-lice. Common soapsuds may also be used for this purpose, but care should be taken to rinse the plants in clean water after using a soap wash.

5. Most plants need some direct sunlight every day if possible, although most of the ferns grow without it.

6. Plants usually need re-potting once a year. Many kinds may be set out-of-doors in flower beds in May and left until September, when they may be taken up and placed in pots, or cuttings made from them for potting.

7. A flower exhibition at the school once or twice a year, or at a local exhibition, adds to the interest.

8. The pupils should report to the teacher from time to time the progress of their plants and make many drawings showing their development.

PLANT CUTTINGS

The pupils will be interested to know that it is possible to produce new plants without waiting for them to grow up from the seed. It will indeed be quite a surprise to them to see a new plant complete in all its parts grow up from a small piece of stem, root, or even leaf. With a little care even children may propagate plants in this way.

SELECTION OF CUTTINGS

Begin with some of the common herbaceous bedding-plants, such as geranium, coleus, or fuschia. These are such common bedding-plants that they are easily obtained in the autumn. Only well-matured stems of the season's growth, such as will break with a slight snap when bent, should be used.

Let the pupils provide themselves with sharp knives for the lesson, with small boxes or pots, and with some moist, clean sand—not potting soil. A few holes should be bored in the bottom of the box, then a layer of fine gravel put in to provide for good drainage, and over it layers of moist sand. Take a slip or growing end of a stem about three inches in length, always cutting it at or

just below a node, or joint, and leaving only a couple of small leaves on the top of the slip. Insert it to about half its depth in the box of moist sand. These cuttings may be placed a few inches apart in the box, which should then be placed in a warm, light room for a few weeks until the roots develop. The cuttings should be partly shaded by papers from the strong sunlight, and the sand kept slightly moist but not wet. Bottom heat and a moist, warm atmosphere hasten their development.

Another very convenient and very successful method of starting cuttings is to take a six-inch flower-pot, put two inches of fine gravel in the bottom, set a four-inch unglazed flower-pot in the centre, and fill up the space around it with sand and garden-loam, mixed. Put a cork in the hole in the bottom of the small flower-pot, and then fill it with water. Put the cuttings around in the space between the two pots and set in a fairly warm room in moderate light.

POTTING OF ROOTED CUTTINGS

When the cuttings are well rooted, which requires from three to six weeks according to the variety and growth conditions furnished, they should be carefully lifted with a trowel and each set in a small pot or can. First put in the bottom a few small stones to secure drainage, and then a little good potting soil. Set the plant in place and fill in around with more soil and pack this firmly around the roots. Keep room in the top of the pot for water. When the new plant has made some growth, it may be shifted to a larger pot. Geraniums and coleus (foliage plants) should not be kept more than two seasons. Take cuttings off the old plants and then throw the latter away.

EVERGREENS

In December make a study of Canadian evergreens, choosing spruce, balsam, and cedar, if available, or substitute hemlock for any one of these.

Compare the general features of these trees, such as shape, direction of branches, colour, persistence of leaves through the winter.

Have the pupils notice how nature fits these trees to endure the snows and storms of winter by:

1. The tapering cone which causes the snow to slide off the tree.

2. The fine, needle-shaped leaves to which only very sticky snow will adhere.

3. The very tough, flexible, and elastic branches, which bend in the wind and under the weight of snow, but spring back to their old positions.

4. The resin in leaves, stems, and buds, which enables the trees to resist frost and rain.

Teach the pupils to distinguish these trees by their differences in colour and form and also by the differences in their leaves and cones.

CLASS-ROOM LESSON

Distribute small twigs of balsam and require the pupils to observe and describe the length, shape, and colour of the leaves.

Next distribute small twigs of spruce and require the pupils to compare the spruce leaves with those of the balsam in length, shape, and colour.

Next distribute twigs of cedar and proceed similarly.

The cones may be dealt with in a similar manner. Require the pupils to make a census of the evergreens of

the locality, recording the class of evergreen, the size, and the use of each kind for shade, ornament, or for commercial purposes.

To the teacher.—The balsam, spruce, and hemlock are difficult for the beginner to distinguish, but this may be done by noting the following points of difference in their leaves:

The leaf of the hemlock is the only one that has a distinct leaf-stalk. Look for this tiny stalk.

The leaf of the hemlock, like that of the balsam, is flat, but the hemlock leaf is much the shorter.

The leaf of the spruce is not flat, but is three-sided or nearly so. Its colour is uniform, while the under surface of the hemlock leaf, and also of the balsam leaf, is of a decidedly lighter colour than the upper surface.

Note that the spruce *type* is studied; no attempt is made at this stage to differentiate the several species of spruce.

COLLECTION OF WOOD SPECIMENS

During the winter months the boys may prepare specimens of wood for the school collection. These specimens should be cut when green, and dried afterwards. They should be uniform in length—not more than six inches—and should show the bark on one side. The side showing the bark should be two inches wide at most, six inches long, and running in a V-shaped, radial section toward the pith. A tangential section also shows well the rounded layers. A piece of slab as cut length-wise off a round stick is tangential. Care should be taken not to mutilate trees in taking these specimens. Specimens of rare or foreign woods may be obtained at wood-working factories.

RELATED READING

Winter is Nature's quiescent period. Continuous active observation in the out-of-doors among the plants of the forest and garden gives place for a time to indoor work and reflection. Pupils need time for reading and reflection, and no time is so opportune as the quiet winter season. During these months some time should be devoted to the reading of nature stories and extracts from magazines and books dealing with plant as well as with animal life.

Pupils should review their gardening experiences and discuss plans of improvement for the approaching spring and summer. Let them write letters to the Form II pupils of other schools where similar work has been carried on, and give some of their experiences in gardening and other plant studies, and also in animal studies. A certain Friday afternoon might be appointed for hearing the letters read which were received in reply. Suitable short poems that have a direct bearing upon the outdoor studies should be read from time to time. Good pictures also come in here as an aid in helping the pupils to appreciate written descriptions. The first-hand observations made by them will form a basis for the better and more appreciative interpretation of these literature selections.

For Observation Lesson on Weed Seeds, see page 171.

HOW ANIMALS PREPARE FOR WINTER

Introduction.— Discuss the preparations that people make for winter, such as the storing of food and the providing of warmer clothes and homes.

Method.—The teacher questions the pupils and encourages them to tell what they have learned through their

own observation of animals. The knowledge of the pupils is supplemented by information given by the teacher, but the pupils are left to find out more facts by further observations. Thus:

Do you ever see ground-hogs out during winter?

What do they feed upon during the winter?

What is the condition of ground-hogs in late summer and in autumn?

What is the use of the great store of fat that they have in their bodies?

Examine the snow near the burrows of ground-hogs and find whether they ever come out in mid-winter.

To the teacher.—The hibernating animals prepare a home or nest and lay up a store of food in the form of fat within their bodies. To hibernate does not mean the same as to sleep. The hibernating animals have much less active organs than the sleeping animals. The heart-beat and the respiratory movements are very slow and feeble, consequently a very little nourishment suffices to sustain life.

SUMMARY OF LESSONS

(Two lessons of twenty minutes)

1. Some animals migrate:
   Examples—many birds, butterflies, and some bats; the cariboo, and buffalo.
2. Some animals hibernate:
   Examples—bear, ground-hog, raccoon, frogs, toads, snakes, and some bats.

NOTE.—Flies, mosquitoes, and some other insects crawl into crevices and remain at rest during winter, but their bodies are not stored with food.

3. Some animals build houses and store foods:
   Examples—beaver, squirrel, chipmunk, honey-bee, deer-mouse.
4. Some animals build homes convenient to food:
   Examples—musk-rat, field-mouse.
5. Some animals put on warmer clothing:
   Examples—fox, mink, otter, rabbit, horse, cow, partridge, chickadee. The rabbit and weasel turn white, a colour protection.
6. Many insect larvæ form cocoons or pupæ cases:
   Examples—emperor-moth, codling moth, tomato worm.

CORRELATIONS

With literature, reading, and language.

With geography: By a lesson on "The influence of climate upon animal and plant life".

CHICKENS

(Consult *Principles and Practice of Poultry Culture* by Robinson. Ginn & Co., $2.00.)

CONVERSATION LESSON

How many of you keep chickens at your homes?

Why do many kinds of people keep chickens?

What breeds of chickens do you keep?

How many other breeds do you know?

Describe the appearance of a few of the commoner breeds.

Why are there so many different breeds?

Name those that are good laying breeds.

Name breeds that are not usually considered good laying breeds.

To the teacher.—Chickens are kept by all classes of people. Many keep them for the profit in eggs and meat, others keep them as a fad, and others to gratify a craving for animal companionship. There are one hundred and seventy-five recognized breeds, varying in size from that of the Japanese bantam weighing ten ounces to that of the huge Brahma which weighs fourteen pounds. The shapes and colours present as great a variation as the sizes. The breeds that are usually regarded as good layers are White Leghorn, Barred Rock, and Rhode Island Red, while the Game breeds are usually regarded as poor layers. Careful tests prove, however, that there are good laying and poor laying strains in every breed, and care must be taken to select from good strains, since the breed is not a sufficient guide.

At the close of the first lesson, assign to the pupils the task of making a chicken census of the district as follows:

1. Request each pupil to count the number of hens under two years old at his home and also to count the hens that are more than two years old.

2. Request each pupil to find out, if possible, the number of eggs obtained at his home during the whole year.

ARITHMETIC LESSON BASED ON THE CHICKEN CENSUS

1. Using the data collected by the pupils, calculate the total number of chickens under two years old in the district.

Calculate the number over two years old. (The latter are classed as unprofitable.)

2. Using the data obtained by the pupils (provided sufficient data was obtained to make it reasonably reliable), calculate the average number of eggs laid a year by each hen.

3. If the data collected by the pupils as to the number of eggs is thought to be unreliable, make use of the following:

The average number of eggs laid each year by each hen in Ontario is seven dozen. Use this average number, and:

(1) Calculate the value of the eggs produced in this district in a year, the average price of eggs being twenty cents a dozen.

(2) If the average production of eggs were increased to ten dozen (a number that is easily possible under improved management), find the value of the eggs that would be produced in a year, and find the gain that would result from this better management.

4. If it costs ninety cents a year to feed a hen, find the net annual profit to this district from the egg production.

CARE OF CHICKENS

The method of developing conceptions of how to take proper care of chickens is based partly upon the pupils' experiences and partly upon a knowledge of the history of the original wild hens.

Information can be gathered from the pupils as to the date of hatching of the earliest chickens and the date at which the pullets begin to lay. Chickens that are hatched in April begin to lay in November or December and lay throughout the winter when eggs bring the highest price.

The original wild hens lived in the dry, grassy, and shrubby jungles of India. They were free to move about in the open air, and at night they perched in the trees, which sheltered them from rain. Hence may be inferred what kind of quarters should be provided for chickens.

CARE AND FOOD OF CHICKENS

Points developed

Chickens must have plenty of fresh air without draughts.
Heat is not necessary.
Their quarters must be dry, clean, and well lighted.
They require exercise.
Their food must have in it the materials that are needed to make the substance of the egg.
Breakfast: Wheat or corn scattered among straw—the scratching affords exercise.
Dinner: Meat scraps, slaughter-house refuse, vegetables, sour milk, and rolled oats.
Supper: As at breakfast.

PHYSICAL SCIENCE PHASE OF NATURE STUDY

The teacher is advised to read carefully the instructions and General Method of Experimental Science, Chapter II before beginning the lessons in Physical Science.

SOLIDS, LIQUIDS, AND GASES

Arrange a collection of objects of various shapes, sizes, colours, and weights, as cork, glass, lead, iron, copper, stone, coal, chalk. Show that these are alike in one respect, namely, that they have a shape not easily changed, that is, they are *solids*. Compare these solids with such substances as water, alcohol, oil, molasses, mercury, milk, tar, honey, glycerine, gasolene. These latter will pour, and depend for their shape on the containing vessel. They are *liquids*. Compare air with solids and liquids. Such a material as air is called a *gas*. Other examples of illu-

minating gas, and dentists' "gas"; others will be studied in future lessons. Pupils may think all gases are invisible. To show that some are not, put a few pieces of copper in a test-tube or tumbler and add a little nitric acid. Watch the brown gas fall through the air; note how it spreads in all directions. Some gases fall because they are heavier than air; others rise because lighter. All gases spread out as soon as liberated and try to fill all the available space. Spill a little ammonia and note how soon the odour of the gas is smelled in all parts of the room.

CHANGE OF STATE

Heat some lead or solder in a spoon till liquid. Let it cool. Do the same with wax.

Heat some water in a flask till it becomes steam. Steam is a gas. Cool the steam and form water again. (See distillation.) Refer to lava (melted rock), moulding iron, melting ice and snow, softening of butter.

All solids may be changed to liquids and even to gases if sufficiently heated. Likewise all gases may be changed into liquids and then to solids.

EXPANSION OF SOLIDS

In winter pupils may find that the ink is frozen. The teacher directs attention to this and inquires why it has occurred. It may be that in a lesson on rocks the teacher will ask the pupils to account for all the little stones. The following *experiments* will aim at solving the foregoing problems:

1. A brass ball and ring are shown. Pupils handle these and note that both are cold and that the ball just passes through the ring. They are asked to compare the size of the ball with that of the ring.

2. The spirit-lamp is lighted and examined. Pupils hold their hands over the flame to note the heat.

3. The ball is heated in the flame for a short time by one of the pupils, and felt cautiously. An attempt is made to pass it through the ring. How has the ball changed in feeling? In size? How does one know it is larger? What has caused these changes?

4. Cool the ball. Feel it. Try to pass it through the ring now. How has it changed in feeling? In size? What caused these changes? How does heat affect the ball? How does cold affect it?

The teacher may now give the words *expand* and *contract,* writing them on the black-board and explaining their use. Pupils may then state their conclusions: *A brass ball expands when heated and contracts when cooled.*

A blacksmith can make the following very serviceable apparatus: A scrap of iron about eleven inches long, one inch wide, and one-eighth inch thick, has one inch bent up at each end. A rod one-eighth inch in diameter is made just long enough to pass between the upturned ends of the first piece when both are cold. The rod is heated and the experiment conducted as in the case of the ball. Two additional facts are learned: (1) Iron expands as well as brass; (2) solids expand in length as well as in volume. The pupils may now be told that other solids have been tried and expansion has invariably followed heating. The conclusion may then be made general.

PRACTICAL APPLICATIONS

1. When your ink-bottle was placed on the stove, which end became warmer? Which expanded the more. Why then did it crack?

2. What other examples like this have you noticed? (Lamp chimneys, fruit jars, stove plates)

3. The earth was once very hot and is now cooling. How is the size of the earth changing? Does it ever crack? What causes earthquakes?

4. Find out by observation how a blacksmith sets tires.

5. Invent a way to loosen a glass stopper stuck in the neck of a bottle.

6. What does your mother do if the metal rim refuses to come off the fruit jar?

7. Next time you cross a railway, notice whether the ends of the rails touch. Explain.

8. What allowance is made for contraction in a wire fence? A railway bridge? Why?

9. Why do the stove-pipes crack when the fire is first started?

10. Why does the house go "thump" on a very cold night?

11. Draw the ball, ring, and spirit-lamp in position.

12. Describe in writing the experiments we have made.

QUESTIONS FOR FURTHER INVESTIGATION

You have seen that iron and brass both expand. Do they expand equally? Let pupils have a few days to invent a way of answering the question. The experiment may then be tried with the compound bar. See *The Ontario High School Physics,* pages 217-218, also *First Course in Physics,* Milliken and Gale, page 144.

If the equipment of the school is limited, it may be necessary to dispense with the ball and ring and generalize from one experiment.

Another easily made apparatus consists of two iron rings with handles. One ring will just pass through the other when both are cold. The stove may take the place of the spirit-lamp.

A still simpler plan consists in driving two nails into a block at such a distance apart that an iron rod (six-inch nail, poker, bolt, etc.) will just pass between. On heating the rod the increase in length becomes evident.

EXPANSION OF LIQUIDS

Fill a common bottle with coloured water; insert a rubber stopper through which passes a glass tube about sixteen inches long. Set the bottle in a pan of water and gradually warm the water. The rise of the liquid in the tube will indicate expansion. On setting the bottle in cold water the fall of the column of coloured water shows contraction. See *The Ontario High School Physics*, page 218, also *Science of Common Life*, page 48. Macmillan Co., 60 cents.

Set the flask or bottle in a mixture of ice and salt and note that the extreme cold causes contraction for a while, then expansion. Note that when expansion begins, the water has not begun to freeze, but that it does so soon after.

The night before this experiment the children should set out in the cold air, tightly corked bottles of water. In the morning they will be found burst by the expansion.

APPLICATIONS

1. Why did some of the ink-bottles burst in the cold room?

2. Find large stones split up into two or more fragments. Explain.

3. Why is fall-ploughed land so mellow in spring?

4. Why does ice float? Think what would happen if it did not.

5. Explain the heaving of oats, clover, wheat.

6. Do all liquids expand on freezing? Try melted paraffin.

THE THERMOMETER

Besides the ordinary thermometer the school should possess a chemical thermometer graduated from 0° Fahrenheit to 212°.

1. Our sensations vary so much under different circumstances and in different individuals that they cannot be depended on. Find examples of this and show the need of a measuring instrument.

2. The pupils can learn, by examination of the common wall instrument, the parts of the thermometer—tube, bulb, liquid (alcohol or mercury), and scale.

3. Repeat the experiment for expansion of liquids, showing wherein the apparatus resembles the thermometer, warm the thermometer bulb and watch the column rise; cool it and note the fall.

4. Set the bulb of the chemical thermomefer in boiling water. The mercury comes to rest near 212°. Bury the bulb in melting snow and notice that the column falls to 32°. Give names for these points. Explain that a degree is one of the 180 equal parts which lie between boiling point and freezing-point. Show that 32° below freezing must be 0°, or zero.

5. The uses of thermometers for indoors and outdoors; for dairy, sick room, incubator, and soils; maxi-

mum and minimum. Dairy thermometers registering 212° Fahrenheit may be obtained; they are cheaper than chemical thermometers.

EXPANSION OF AIR

Half fill a flask with water and invert it uncorked over water in a plate. Apply a cloth soaked in boiling water to the part that contains air. Why does the water leave the flask? Apply cold water. Why does the water return? Any ordinary bottle may be used in place of the flask, but it is more liable to crack.

Make an air thermometer. See *The Ontario High School Physics,* page 223, also *Science of Common Life,* page 41. Try to graduate it from the mercurial thermometer. Have the boys make a stand for it.

Inferences.—Heated gases rise because they expand. Hot-air balloons, winds, and heating with hot-air furnaces, all depend on this principle.

SOURCES OF HEAT AND LIGHT

NOTES FOR A SERIES OF LESSONS

1. The Sun.—Our dependence on it. Valuable results of its heat. Simple notions as to its size, distance, and nature. Our earth catches a very small fraction of the sun's heat; our sun is but one of millions—the fixed stars. Show the burning effect of a lens.

2. Fuels.—Wood, oil, coal, alcohol, gas, peat, straw; where obtained; special uses of each under varying conditions; need of economy. (This is closely related to geography.)

3. Electricity.—In urban schools use the electric light or some heating device for illustration. In rural schools a battery of two or three cells (see "Apparatus") will melt a fine strand drawn from a picture wire.

Applications: ironing, toasting, cooking; advantages or disadvantages compared with gas or wood.

4. Friction.—Pupils rub hands together; rub a button on a cloth; saw a string across the edge of a board or across the hand; bore a hole through a hardwood plank, then feel the auger-bit.

Applications: restoring circulation; "hot-boxes" in machinery; lubricants and their uses; lighting matches.

5. Pounding.—Hammer a nail flat on an anvil or stone; feel it. Bullets fired against an iron or stone surface may be picked up very hot. Note sparks that can be struck from a stone; percussion caps, flint-lock muskets.

6. Pressure.—After using a bicycle pump for some time, feel the bottom, also the top. If possible, examine an air-compressor and find out the means used for cooling the air.

7. Sources of Light.—Sun, moon, oil, tallow, gas, electricity, wax, acetylene; advantages of each; relative cost.

Primitive Methods of Obtaining Fire: Most savages obtain fire by friction; rubbing two pieces of wood together till hot enough to set fire to some dry, light material. The natives of Australia placed a flat piece of wood on the ground and pressed against this the end of a round piece, which they twirled rapidly with their hands till fire was produced. The North American Indians did the twirling with their bow strings; the Eskimo's plan is

somewhat similar. It is impossible to say when flint and steel were first used, but we know they continued to be the chief means of producing fire till about 1834, when matches were invented. Let pupils try to produce fire by these means.

The earliest lamps consisted of shells, skulls of animals, and cup-shaped stones filled with fat or fish oils which burned on a wick of cloth or the pith of rushes. The Tibetans burn butter, the Eskimos whale- or seal-oil, the Arabians palm- or olive-oil. For outdoor lighting, torches carried in the hand were used till gas came into general use about 1792.

CONDUCTION

Give to four boys strips of copper, aluminium, wood, and glass, respectively. They hold these by one end and heat the other end till one or more are forced to drop the piece on account of the heat. The boys with the metals will soon find them hot throughout, but the other two will be able to hold on indefinitely. The teacher gives the terms "good conductor" and "poor conductor".

PROBLEMS

1. Are metals generally good conductors? Try with strips of zinc, lead, iron, a silver spoon.

2. Are all good conductors equally good? Devise a means of ascertaining. See *Science of Common Life,* Chapter VI; also *The Ontario High School Physics,* page 274.

3. Is water a good conductor?

Lists of good and poor conductors may then be made, the teacher adding to the list. Good: metals; poor: wood,

horn, bone, cloth, leather, air, water, hair, asbestos, ashes, rock, earth.

PROBLEMS

1. If the interior of the earth is very hot, why do we not feel it?

2. How can the cold snow keep the earth warm?

3. Why does your hand freeze to metals but not to wood?

4. Let the children try to find other instances: wools or furs for clothing, fur coats on northern animals, feathers on birds, down quilts, tea cosies, sawdust for packing ice, double windows, wooden handles for hot irons, asbestos coating for steam pipes.

THE MINERS' SAFETY-LAMP: This is a most important application of conduction. Get from the tinsmith a piece of brass gauze six inches square. Raise the wick of the spirit-lamp causing it to give a high flame and bring the gauze down upon the flame till it touches the wick. Note that the flame does not rise above the gauze. Hold a piece of paper above the gauze near the flame and note that it does not take fire. Note also that the gauze soon becomes hot. The brass wires conduct the heat of the flame rapidly away so that there is not heat enough above the gauze to cause combustion. Now roll the gauze into a hollow cylinder, pin the edges together, insert a cork at each end, and have a short candle fastened to the lower one. Try to light the candle with the lamp through the gauze. It is not easily done.

The miner carries a lamp made like this, so that if he should be in the presence of the explosive gas, "fire damp", it would not explode because of the wire gauze shield.

CONVECTION

Water is not a conductor, how then is it heated?

Drop a few pieces of solid colouring matter, (analine blue, blueing, or potassium permanganate) into a beaker of cold water. Place the beaker over a heater and observe the coloured portion rise.

Wet sawdust will make a good substitute for the colouring matter. A sealing jar or even a tin cup will do instead of the beaker. The stove or a dish of hot water will take the place of the lamp.

PROBLEMS

1. Using a thermometer, see whether the water at the bottom is warmer than that at the top while the beaker is being heated.

2. Heat some oil and pour it over the surface of some cold water. Lower a thermometer into this. Does the water at the bottom soon become warm?

3. If your kitchen is provided with a hot-water tank, find out what part of the tank first becomes warm after the fire is lighted.

4. In bathing, where do you find the coldest water of a pond or still river? See *Science of Common Life,* Chapter VI; also *The Ontario High School Physics,* page 280.

CONVECTION IN GASES

A good apparatus may be made by cutting two holes one inch in diameter in one side of a chalk box, replace the lid with a piece of glass, place a lamp chimney over each hole and a lighted candle under one of the chimneys. Hold a piece of smoking touch-paper at each chimney in turn and note direction of air current.

APPLICATIONS

1. Winds are caused by the rising of air over heated areas, allowing cooler currents to take its place. (Geography)

2. Rooms are ventilated by heating some of the air more than the rest, thus producing a current. (Hygiene) Winds are nature's means of ventilating the earth.

RADIATION OF HEAT

This should be taken up as an introduction to dew, frost, winds, climate, etc.

1. Make an iron ball hot (the end of a poker will answer). Hold the hand a few inches below the iron. Does the heat reach the hand by convection? By conduction? By means of suitable questions, lead the pupil to see that it is not by convection, for the hand is below the hot object while heated air rises; it is not by conduction, for air is one of the very poorest conductors; moreover, the heat is felt instantly from the poker, but it takes an appreciable time for it to come by conduction and convection. We say this heat is *radiated* from the iron. The velocity of radiated heat is about 186,000 miles a second.

2. The above experiment may be varied by bringing the hot iron gradually toward the bulb of the air thermometer and noting the greatest distance at which it will affect the thermometer.

It is by radiation that the sun's heat and light reach us. We get much of the heat of stoves, fire-places, and radiators by the same means.

Why does the earth cool off at night? Why does dew form? Why can no dew form on a cloudy night? Why is a mountain top or a desert so cold, especially at night?

3. Take two tin cans (baking powder boxes will answer) and make holes in the lids large enough to admit a thermometer. Blacken one box in the flame of an oil lamp. Fill both with boiling water and put in a cool place. Test with a thermometer from time to time. Which cools most rapidly?

4. Fill the tin cans with cold water, find the temperature, and then place them near a hot stove. Which warms faster? Usually dark or rough surfaces radiate heat and absorb heat faster than bright or smooth ones. An excellent way of testing this is to lay a black cloth and a white one side by side on the snow where the sun is shining brightly. The snow will melt more rapidly under the black cloth. Painted shingles may be substituted for the cloths. Try different colours. The day chosen should not be extremely cold.

PROBLEMS

1. Why should we have the outside of a tea-kettle, teapot, or hot-air shaft of a bright colour? Why should we have stoves and stove-pipes dull black?

2. Why does a coat of snow keep the earth warm?

3. Which is the warmest colour to wear in winter? Does this account for the colour of Arctic animals?

4. Which is the coolest colour to wear in the hot sun?

5. Gardeners sometimes strew the ground with coal-dust to help ripen their melons. Show the value of this.

6. Suggest a method of protecting a wall from the heat of a stove.

CHAPTER XI

FORM III

SPRING

WINDOW BOXES

MANY garden plants should be started in a box of earth in a warm, sunny window. In some schools this can be done with a little care in heating on cold nights. Small boxes or grape baskets full of rich sandy loam with an inch of gravel in the bottom for drainage may be used. Sow the seeds in rows or broadcast. To prevent the soil from drying out too quickly, cover the box with a pane of glass. When the plants are up, give them plenty of light and not too much warmth. On very mild days set them in a warm, sheltered place out-of-doors and bring them in again early in the evening. This tends to make them hardy. When about three inches high, pick the young plants out and set them in other boxes a few inches apart. This moving causes the formation of numerous fibrous roots and makes stronger plants.

WINDOW GARDENS

Window boxes may be used for a whole season on the inside of the building in cold weather, and on the outside in warm weather. There is almost no limit to the kinds of plants that can be grown in them, but they are most suitable for flowers.

Good boxes may be made of dressed lumber so as to fit on the window-sill. They should be six inches deep,

ten inches wide, and the required length. They should have a few small holes in the bottom to allow excess water to drain off and should be painted dark green or some quiet colour. There should be an inch of gravel in the bottom, some rotted sods covering this, and then the box filled with rich sandy loam.

SUITABLE PLANTS

Some flowers suitable for growing in window boxes outside in summer are those of drooping habit: lobelia, Kenilworth ivy, verbena, tropeolum, petunia, and sweet-alyssum toward the front, and behind, more erect plants, such as geranium, heliotrope, begonia, phlox, and nasturtium. The box must not be too much crowded.

For inside and in shady situations the following are suitable: tradescantia, parlour ivy, moneywort, vinca smilax, climbing fern, asparagus fern, dracæna, coleus, centaurea, sword fern, and Boston fern. For indoor boxes in winter, the following may be used: abutilon, calceolaria, cyclamen, violets, primroses, petunias, geraniums, freesia, and such foliage plants as dracæna, cannas, dusty miller, and coleus. The following climbing plants may be trained up the window cases: asparagus plumosus fern, cobea scandens, smilax, maurandia, and English ivy. If drooping or trailing plants are desired, the following may be used: oxalis, sweet-alyssum, lobelia, ivy, geranium, Kenilworth ivy, and Wandering Jew.

FERTILIZER

As the amount of soil is limited and the number of plants that it has to support is great, the soil should be made quite rich and should be further fertilized from time

to time with a little liquid manure. This can be best obtained by taking a strong barrel or large keg and filling it about half full of water. Then fill an ordinary coarse potato sack with cow-stable manure and set the sack in the barrel for a few days. A tap in the bottom of the barrel is most convenient for drawing off the liquid manure. A little of this will also be found valuable for watering dahlias, roses, and other garden plants during the summer.

SOIL STUDIES

The classes of soil should be reviewed. Pupils should gather examples from many places. The samples may be kept in bottles of uniform size and should include not only the four types but varieties of each, also various kinds of loam.

EXERCISES AND EXPERIMENTS

SOIL CONSTITUENTS

1. With a sharp spade, cut a piece about twelve inches deep from (1) the forest floor, (2) an old pasture field. Note character and order of the layers of soil in (1) leaves, humus, loam, sand, or clay; in (2) grass, dead grass, humus, loam, sand, or clay. Observe soils shown in railway cuttings, freshly dug wells, post holes.

2. Note the effect produced on the soil of a field by (1) leaving it a few years in pasture, (2) ploughing in heavy crops, (3) applying barn-yard manure. In all these cases vegetable matter is mixed with the soil.

3. Dry some good leaf-mould. Throw a handful on the surface of some water. The mineral matter sinks, while the vegetable portion remains suspended for some time. Try this experiment with gravel, sand, and clay. Note

that the gravel sinks rapidly, the sand less rapidly, and that the clay takes a long time to settle. If the water be kept in rapid motion, the finer soils will all remain suspended till motion becomes slower. Apply this in geography. The bed of a stream will consist of stones if it be swift, of sand if less swift, and of clay if very slow. How are alluvial plains formed?

4. Place half an ounce of dry humus on an iron plate or fire-shovel and heat strongly in a stove. Note that it begins to smoke and a large part smoulders away to ashes; the mineral portion remains. Weigh the part left and find what fraction of the humus consisted of vegetable material.

Try to find the proportion of vegetable matter in each of the following: loams from various sources, sand, clay, gravel. The last three will show scarcely any change. This experiment will give rise to some good arithmetical problems in fractions.

WATER IN SOILS

5. Compare a handful of fresh garden soil with the same soil dried. Note the glistening of the fresh soil, also its weight and darker colour. The fresh soil admits of packing though no water can be squeezed from it. In its best condition, the water of the soil adheres as a film of moisture about every particle. Free water is to be avoided since it excludes the air from the soil.

6. Equal weights of soils of different kinds and degrees of fineness are placed in funnels or in inverted bottles with bottoms removed. Water is then slowly added to each until it begins to drop from the lower end. From this

is seen (1) the great value of humus as a water holder, (2) the advantage of fine soil over coarse. For retention of water by absorption, consult *Nature Study and Life,* Hodge, page 382.

7. Take two wooden boxes (chalk boxes will do), fill one box with moist sand and the other with moist leaf-mould. Weigh the boxes separately and leave them for three or four days in a warm room. Weigh again and note decrease from evaporation. The sand dries out much faster than the humus. Test with clay, gravel, and loam, also with mixtures of these and leaf-mould.

8. Take three paint cans; punch holes in the bottoms. Fill each with good soil well shaken down. Stand the cans in water till the tops are moist, then place them in a warm, dry place. Loosen the soil on the top of No. 1 to a depth of one inch; on No. 2 to a depth of two inches; leave No. 3 untouched. Find out after a few days which is drying out fastest. How may soil be treated so as to lessen evaporation of water?

DRAINAGE

9. Gravel and sand allow water to run away rapidly, but where the soil is fine or closely packed as in clay soils, under-drains are necessary (1) to carry off the surplus water, (2) to allow air to enter the soil, (3) to warm the soil (wet soil is colder than dry).

Take two equal-sized tin cans, make several holes in the bottom of one, place therein a layer of broken pottery or stones, and fill with good soil. Fill the other with similar soil but make no holes for drainage. Plant in each can a healthy plant of the same size and kind. Water both till the soil is saturated and continue watering every

two or three days for six weeks. Note (1) the progress of the plants, (2) the temperature of the soils, (3) which plant has the largest and deepest roots. (See *Bulletin 174*, Ontario Department of Agriculture.)

10. Take five equal-sized boxes, provide for drainage, and fill No. 1 with wood, earth, or humus, No. 2 with clay, No. 3 with sand, No. 4 with a mixture of clay and humus, No. 5 with a mixture of sand and humus. Plant corn in each box, set in a warm room, and keep watered for two or three weeks. Note in which case growth is most rapid. Set boxes in a dry place and cease watering. Which suffers most from the drought? Which bakes hardest in the sun? Test the temperature of each after watering and standing in the sun for an hour. Sand is warmer than clay, also the presence of humus raises the temperature. This item is important, since most seeds decay instead of sprouting if the temperature is below 45° Fahrenheit.

11. Enumerate the services rendered to the soil by humus.

12. In Experiment 10, let the corn grow for some time and determine whether the very rich humus is the best in the end. Sand and clay are almost altogether mineral; leaf-mould almost entirely organic; neither alone is good, but a mixture gives the best results.

GARDEN WORK

The boys of this Form should attend to the fertilizing and spading of the plots belonging to the girls of their Form. The girls themselves can do all the rest of the work, and they should try to keep the plots level, uniform in size, and in a straight line. If the corner posts are kept

in line and the plots made up the exact size, the appearance of the garden will be greatly improved.

The pupils are now old enough to make their own choice of flowers and vegetables. Very tall growing plants, such as corn and sunflowers, are not desirable in individual plots as they shade other plants near them. Corn is best grown in a large plot about twenty feet square. The same may be said of vines, such as cucumbers, melons, squash, etc. If the plots are small, it is better to plant but a single variety, but in large plots from two to four varieties may be arranged to advantage. Usually rows of vegetables, such as carrots and beets, may be placed a foot apart, cabbage about twice that distance, and tomatoes a little farther apart than cabbage.

Generally speaking, plants should be placed so that when full grown they will just touch, cover the ground completely, and thus prevent the growth of weeds.

As soon as the young plants appear above the ground, light cultivation with rakes and claw-hand weeders should be started, so as to keep weeds from growing and at the same time to provide a loose surface or earth mulch for conserving the moisture and aerating the soil. Thinning should also be begun when the plants are quite small, but it should not all be done at once. As the plants increase in size, the best ones should be left and the poor ones taken out. In some cases plants thus removed may be re-set to fill vacant places.

TREE SEEDS

Tree seeds that have been stored over winter should now be planted in rows in a small plot. The rows should be a foot apart and the seeds quite close together in the row. A cheese-cloth or slat shade should be used on this

plot, as the hot sun is too strong for tree seedlings when they first come up. They should have cultivation every week and watering in dry weather. Always water in the evening after school, or even later when possible.

TRANSPLANTING

Pupils in this Form should have practice in transplanting, as well as in sowing seed. For this purpose seeds should be started about the first of April in hotbeds or window boxes, seedlings transplanted into cold frames when two or three inches high, and then set out in the garden in the latter part of May when danger of frost is past.

TRANSPLANTING FLOWERS AND VEGETABLES

Choose, if possible, a cool cloudy day. Water the plants thoroughly in the hotbed or cold frame a few hours before lifting them. Lift them with a trowel or small spade, and keep as much earth on their roots as possible. With a transplanting trowel, make holes deep enough so that the plant will be a little deeper in the soil than before transplanting. Unless the soil is moist, a little water put in the hole with the plant is beneficial. The evening is considered best for transplanting if the weather is clear. If the sun is very hot, the plants should be shaded for a few days until the roots become established and begin their work. Shingles slanting over the plants from the south side and driven into the ground to hold them in position are best. Papers held by means of two stones also give good results. The practice of covering them with inverted cans is not a good one, as the light is almost completely cut off. A few holes in the can would help considerably. Care must be taken to pack the earth firmly about the roots.

Watering again twenty-four hours after transplanting is often necessary. If the plant has a leafy top, it is best to take off some of the leaves, as they tend to give off water more rapidly than the roots can at first take it in.

TRANSPLANTING TREE SEEDLINGS

Nuts and other tree seeds collected the previous autumn should now be planted in the forestry plots in rows a foot apart. As the seeds may not all grow, they may be planted close together in the row and thinned out the following spring if necessary. They need some shelter from the sun the first summer. In large plots this is provided by means of a slat covering, but in a small plot cheese-cloth tacked on strips and fastened on corner posts is satisfactory. When a shower comes, this cheese-cloth screen should be removed so that the rain may moisten the plot evenly. Seedlings may be transplanted from the woods or from the forestry rows before the leaves open out.

BUDDING

In budding, a slit like the letter T is made in the side of the young seedling close to the ground. The bark is raised a little at the point where the vertical slit meets the horizontal one, and a bud of desired variety with a shield-shaped bit of bark (and perhaps a little wood) attached to it is shoved in and the sides of the slit bound down upon it. After the bud, or scion, has started to grow, the stock is cut off an inch above the point where the bud was inserted. The bud then makes rapid growth, and in two years the resulting tree is large enough to set in its permanent place in the orchard.

CUTTINGS

Pupils in this Form should try to grow such woody plants as roses and grapes from cuttings. Roses are frequently propagated by budding, as in the case of apples and peaches. They may also be grown upon their own roots or from stem cuttings. Such cuttings should be from well-matured wood of the present year taken in the autumn and packed in moist sand over the winter. Make the cuttings about three inches in length. The top end should be cut off immediately above a bud and the bottom end just below a bud, as roots seem to start more readily from a node, or bud. Such a cutting may have three or four buds of which only the upper two need be left. If both of these grow, the poorer one may afterwards be removed.

These rose cuttings should then be inserted in a box of clean, moist sand to a depth of two inches, kept in a warm room, and shaded with a sheet of newspaper when the sun is very bright. Keep the sand moist but not wet, and when possible have gentle bottom heat. When roots have made some growth, transplant carefully into small flower-pots, using fairly rich, clay loam. In a few weeks they will be ready to plant out in the garden.

Grape cuttings should be taken late in the fall when the vines are well matured. Such a cutting includes only two joints, the upper one being the growing end and the lower the rooting end. They must be stored over winter in cold, moist sand, but should not be permitted to freeze. As soon as the ground can be prepared in the spring, set them out. They should be placed on a slant of about forty-five degrees and covered all but the top bud.

LEAF CUTTINGS

Some plants with large and vigorous leaves, such as many of the begonias, may be propagated by means of leaf cuttings. Buds readily develop from cuts made in the large veins. Take a full-grown healthy leaf and remove the stem all but about half an inch. Make a few cuts across the larger veins on the under side of the leaves at points where main veins branch. Press the leaf firmly down on the top of a box of moist sand with the under side next the sand. Keep the leaf in this position, using small stones or little pegs pushed through the leaf into the sand. Put the box in a warm room and do not let the sand become dry. When roots strike into the sand and buds develop from the points where the veins were wounded, take a sharp knife and cut out the new plant from the old leaf and transplant it into a small flower-pot in good soil. Sink the pot in a box of moist sand to prevent its drying out.

ROOT CUTTINGS

Such plants as "sprout from the roots" may be propagated by root cuttings. Sections of underground stems may also come under this heading, as in the case of horseradish cuttings. But real roots may be used for cuttings, as in the case of the blackberry and raspberry. The roots should be cut in pieces three or four inches long, planted in a horizontal position, and entirely covered with two or three inches of soil.

LAYERING

Bush fruits, such as currants and gooseberries, are frequently propagated by stem cuttings, as in the case of

roses. Another method, which is known as layering, consists in bending one or more of the lowest branches down against the ground, fastening it there by means of a forked stick, and then covering it with two or three inches of earth. The part in contact with the moist earth will send out roots, while one or more shoots will come up. When roots and shoots have developed, the branch is severed from the parent bush and the new plant set in its permanent place. Strawberries exhibit a sort of natural layering.

PLANTING AND CARE OF HERBACEOUS PERENNIALS

Perennials grown from seed the previous summer should now be set in clumps two or three feet apart in the perennial border or here and there beside the fences or walks. The soil should be made fine and fertilized with well-rotted manure from the compost heap before setting out the young perennials. Dahlias and gladioli which were taken in in the autumn should now be set out. The dahlias should be divided and only the best roots used. Other perennials that have grown into large clumps should be dug up, divided, and re-set in well-fertilized soil.

GARDEN STUDIES

Pupils in this Form have now had enough experience in the growing of vegetables and flowers to allow them to make intelligent variety tests. They should grow some of the less familiar varieties and report on the merits of each variety tested. This, however, should not be carried on to the exclusion of the well-known standard varieties. Let the pupils consult the best seed catalogues available and choose for themselves some varieties not already known

to them. They should keep a systematic record of all varieties grown and the methods used in cultivating, fertilizing, etc. The knowledge thus gained will be of value in after years, and the homes will also benefit by it.

BIENNIALS

The pupils should observe the second year's growth of biennials. A special plot in the school garden should be set apart for this purpose. Have them plant in it a turnip, a carrot, a beet, a cabbage, or any other garden biennial saved over winter for the purpose. If desired, the pupils might grow their own seed of these varieties. Notice (1) what part of the plant has become enlarged with stored up food and how big it is when planted, (2) how this part changes in size and texture as the flowers and seeds develop, (3) in what way this extra food seems to have been used.

WILD FLOWERS

STUDY OF THE TRILLIUM

The pupils bring the plants for the lesson. There should be a few purple trilliums among the white, and some of the plants should have the underground parts intact.

Discuss with the collectors their observations on where the trilliums grow, the kind of soil, the depth of the root-stocks below the surface, the uses of the root-stocks, insect visitors.

CLASS-ROOM LESSON

The pupils are directed to examine the plant and flowers and find out all the means for attracting insects.

Find out why the purple trillium attracts flies and beetles, while the white trillium attracts bees and butterflies.

Look into the top of the flower; what figure do the tips of the six flower leaves form?

Using the names calyx and corolla, describe the circle of flower leaves as to number, colour, and relative position.

Find the stamens and describe as to number and position; find out how the stamens are fitted to ensure that the pollen will get upon the visiting insects.

Find the pistil and describe its shape. How is the stigma fitted for receiving the pollen that is carried by the insect visitors.

To the teacher.—The trilliums attract insects by their large white and purple flowers, which are held up by their long stalks high above the three broad leaves. The strong carrion-like odour of the purple trillium is attractive to flies and beetles, while bees and butterflies find the fragrance of the white trillium more to their liking.

The root-stock serves as a buried store of food to tide the plant over the drought of late summer and the severe cold of winter. The well-stocked cellar also explains the flourishing condition of the plant in early spring. The six stamens stand on close guard around the pistil, and insects forcing their way to the nectaries are well peppered with pollen.

Continue the observation work by means of field exercises such as the following:

What change takes place in the colour of the white trillium as it grows old?

Find the ripened seed pods of the trillium, open them, count the number of chambers, and examine the seeds.

Do trilliums grow from the same root-stock year after year?

As correlations, represent the trillium in colour and design an embroidery pattern based on it.

Lessons similar to that on the trillium may be based on adder's tongue, Indian turnip, Dutchman's breeches, violet, and clover.

ADAPTATIONS OF ANIMALS

It is not considered necessary to go outside the list of ordinary animals to find sufficient illustrations of adaptations, and it is recommended that attention be given to these during the study of animals prescribed for the regular Course. This may be supplemented by an occasional review of adaptive features for the purpose of emphasizing the general fitness of animals for their varied habits and surroundings. Care must be taken lest the attempt to explain structures by adaptation be carried to an extreme, for it is impossible to account for all the variations in animal forms.

The following list contains a few of the many examples of adaptations to be met with in the Course prescribed for Forms II and III.

The horse walks and runs on the tips of its toes; this gives greater speed.

Wild animals of the cow and deer kind can swallow their food hastily so that they may retire to a safe retreat; there they regurgitate the food and chew it. The domesticated animal retains this habit, though there is no longer a need for it.

The wood-hare's fur is brown in summer, hence its enemies cannot see it against the brown grass and moss;

in winter its colour is white, which, against the snow, is a protective colour.

The porcupine is very slow, but its colour and shape make it almost impossible to distinguish from a knot on a log. Its quills form an effective protection when it is discovered.

The feet of the squirrel are adapted for climbing and its teeth for gnawing wood and for opening nuts. The tail serves as a balancing pole for leaping from tree to tree and in winter it acts as a protection from cold.

The earthworm's shape and movements are suited to its habits of burrowing through the soil. Its habits of swallowing the soil fit it for burrowing and for obtaining its food at the same time.

Many insect larvæ, as the tomato worm and the cabbage-worm, are of the same colour as the plants on which they feed, and this enables them to escape detection by birds.

The larvæ of dragon-flies and May-flies breathe in water by means of gills very much as fishes do, but the adult forms are suited for breathing in air.

Female birds are usually dull gray or mottled, so that their colours blend with their surroundings while they are nesting, and hence they do not attract the notice of their enemies.

Birds that swim have webbed feet, which act as oars for pushing them through the water. Their feathers are compact and soft for warmth, and these properties, together with oil on their surfaces, make them waterproof.

The tongue of the woodpecker is long, spear-shaped, and sticky; hence it is adapted for catching insects in the holes pecked into the wood.

The tongue of the toad is fastened at the front end, so that a flap can be shot out for more than an inch in front of the animal, thus enabling it to catch insects on its sticky surface.

The toes of the frog are webbed to make them more serviceable in swimming.

The tail of the musk-rat is strong and broad like the blade of an oar and serves the same purpose as an oar.

The tail of the fish is more serviceable for swimming than legs would be.

BIRD TYPES

WOODPECKERS

Woodpeckers are easily distinguished from other birds by their habit of perching in a vertical position on the trunks of trees with the tips of their tails pressed against the bark. While in this position, they tap upon the tree with their sharp, pointed beaks.

THE DOWNY WOODPECKER

Learn to recognize the smallest of our woodpeckers, the Downy. Winter or summer it may be found among the apple trees and shade trees, a tiny black and white bird little bigger than a wren.

OBSERVATIONS

I

Why is "checkerboard" a good name for this bird?
Are there any distinct lines of white?
Are there any patches of red?
Do its movements reveal energy or listlessness?

How does it move up a tree trunk?
How does it move down a tree trunk?
Find out how it can hold so firmly to the trunk.
Does it use its sharp beak as a drill or as a pick?

To the teacher.—The downy is spotted black and white, with barred wings and a white line down the centre of the back. A bright scarlet crown is the colour distinction of the male. This little bird is the embodiment of energy and perseverance. It hops nimbly up the trunk, tapping here and there with its beak, and then listening for the movements of the disturbed wood-borers. If it wishes to descend, it wastes no time in turning around, but hops backward down the trunk, or jumps off and flies down.

II

Examine an apple tree upon which a downy has been at work and find out what it was doing there.

Do you find the birds in pairs during winter? During summer? Distinguish the male from the female.

Tie a beef bone with scraps of meat adhering to it to a tree. What birds come to it?

Find the nest of the downy and describe the nest and the eggs.

Do the holes made by the downy injure the trees?
Why should the downy be welcomed in our orchards?
Describe the sounds made by the birds.

To the teacher.—Discuss the pupils' answers to the above problems in the class lesson, using a picture of a woodpecker to illustrate the features of the bird that adapt it for its habits. Examples: the straight, sharp beak suited for drilling; the two backward, projecting toes for perching; the spines on the tips of the tail feathers to act as a prop.

The downy woodpecker is very useful in the orchard, because it destroys great numbers of larvæ of the tussock-moth and other insects. The holes made in the bark have never been found to injure the trees. The nest is made in a hollow tree, the entrance to it being almost perfectly round and about one and one-quarter inches in diameter.

The downy woodpecker has a very unmusical voice, but fortunately he is aware of this deficiency, and his only attempt at music is drumming with his beak upon a hollow limb or tree.

The hairy woodpecker, redheaded woodpecker, flicker, and yellow-bellied woodpecker (sapsucker) are other varieties which visit the orchards and are suitable for lessons similar to these on the downy woodpecker. They are all beneficial birds.

FLYCATCHERS

Members common to this class are: king-bird; house-phoebe, wood-phoebe, or pewee; whip-poor-will; least fly-catcher; giant fly-catcher.

Direct the observations of the pupils to the following type features:

Brownish or grayish colours; fringe of long bristles around the mouth (explain their use); whistling notes, varying with the different members of the family; habit of jumping from the perch, catching an insect while on the wing, and returning to the spot from which the flight began; nests, chiefly of mud built in a protected place, as under a bridge, ledge of rock, or projecting log.

WRENS

The house wren may be studied as a type. Observe its brownish colour, faintly mottled; its small size and ener-

getic movements, its tail turned nearly vertically upward. Observe and report on other wrens, noting any differences.

CABBAGE-BUTTERFLY

Have a plant of wild mustard or a cabbage growing in a pot. In June, have the pupils, by means of the insect net, catch a number of the white butterflies, the adults of the cabbage-worm.

Place the butterflies in jars or bottles and observe them. Make drawings of them.

Direct the attention of the pupils to the difference between the wings of the male and those of the female. The former has only one dark spot on the front wing, while the female has two spots on this wing.

Release the males and put the females in a vivarium with the potted plant. (A pasteboard box, with a large piece cut out and the opening covered with gauze, makes a good substitute for a vivarium in this case.)

Observe the laying of the eggs. How many are placed at one spot? How are the eggs protected? The eggs may be gathered from the cabbage plants in the garden.

Observe and record the hatching of the tiny worm, its feeding, growth, forming of chrysalis, development into adult.

Frequently little yellow silken cocoons are found in vivaria where cabbage-worms are kept; these are cocoons of a parasite (braconid) that infests the worm.

Because of the ease with which the cabbage-butterfly may be obtained and the rapidity of its development in the various stages, it is very suitable as a type for the study of metamorphosis.

The sulphur, or puddler (called by the latter name because of its habit of settling in groups around the edges

of the water holes), is also a suitable type. The larvæ in this case must be fed on clover.

THE TUSSOCK-MOTH

Begin the study of this insect in June and July by observing the larvæ feeding on the foliage of the horse-chestnut and other shade trees, and direct attention to their destructiveness.

In observing the larvæ, note the size, movements, legs, colour, coral red head, tufts of hair on the back, and the three long plumes.

Watch the birds among the trees to discover whether they eat the larvæ.

Of what use are the tufts of hair? Do the larvæ feed by biting or by sucking? Describe the damage done by the larvæ.

Collect a number of these larvæ and place them in the vivarium with some twigs of horse-chestnut. Observe the spinning of the cocoon and, about two weeks later, look for the emergence of the adult moths.

Observe the two kinds of insects. Describe each. Are there any differences in the cocoons from which they emerge?

Which form of insect places the egg mass and is therefore the female? Note the number and shape of the eggs and how they are protected.

The female moths have no wings and do not move far from the cocoons from which they emerge, while the males have the power of flight.

As outdoor work, look for the egg masses on trees and fences and devise means of combating the tussock-moth.

Gathering and destroying the egg masses during the winter is found to be fairly effective in checking these

insects. Since the cocoons frequently contain parasites that prey upon the larvæ, it is advisable that only the cocoons that have egg masses attached to them should be destroyed; the others are harmless and may contain the useful parasites.

The egg masses may be kept over winter in a box in a cool place, and the hatching of the tiny larvæ and their subsequent rapid growth observed.

POTATO BEETLE

The eggs of this beetle may be found in early summer in clusters on the under surfaces of the leaves of potato plants.

Egg.—Observe the size, colour, shape, position, and number in a cluster; appearance of head from outer end after a week.

Larva.—Observe the colour, shape, head, legs, voracious appetite, movements, rapid growth, destructiveness.

Pupa.—Observe the larvæ disappear from the plants; a search underground reveals the resting stage, or pupæ. After ten days, the adult beetles emerge.

Adult.—Observe the colour, the hard shell covering the head; the hard outer wings and membraneous inner wings; the hard shell on the under surface of the body; the feelers, and legs.

Why will spraying with a poison, such as paris-green, kill these insects?

REFERENCES

Dearness: *How to Teach the Nature Study Course Stories in Agriculture, Bulletin No. 124*

FISH

The Nature Study lessons must be based upon observations of the living fish, preferably in May or June, Sep-

tember or October. The best place for this is on the bank of a clear stream from which it is possible to observe the fish in their natural environment. Here their life activities, their struggles, their conquests, and silent tragedies are enacted before the eyes of the observer. Many observations may be made in this way which will create a life-long interest in these reticent, yet active creatures. Since this method of study is practicable in but few cases, the study of the living fish in the aquarium is the best available substitute.

The teacher or the boys of the class can catch a few fish of three or four inches in length and carry them in a jar of water to the aquarium. Minnows, chub, perch, catfish, or other common forms will do.

OBSERVATIONS

I

The general shape, and the suitability of the shape for swimming.

The surface of the body and the protection it affords. Note the scales and the slime, the latter a protection against the growth of fungi, etc.

The gills—two openings behind the flaps at the rear of the head. The colours, and their value in concealing the fish. The dark upper surface makes it inconspicuous from above; the light under surface blends with the shadow and dims it.

The divisions of the body—head, trunk, and tail.

Movements of the fish and the part that the various fins play in these movements.

Note that the broad tail fin is the most useful fin for locomotion, the others act as balancers or as brakes, or for

causing currents of water near the gills. Observe the movements of the pair of fins nearest the gills, the movements of the mouth, and the currents of water entering the mouth and passing through the gill slits. When a fish is kept in a very small quantity of water, observe the effect produced on the movements of the mouth and gill flaps. What are the uses of these movements? The pupils will thus discover the nature of the respiration of the fish. Why do fish die if many are kept in a jar of water?

II

By supplying various foods learn what kinds are preferred. Find in the actions or habits of the living fish evidences of a sense of smell, of sight, of hearing, and of taste.

Nearly all the following points of detailed study can be observed from the living fish: shape; size; tongue; teeth; gill slits leading from the mouth to the gills; nostrils, number and position; eyes, absence of eyelids; fins, size, build; the arrangement of the scales.

PROBLEMS

Why does the fish require a large mouth?

How are the eyes protected? Compare the shape of the eye with the shape of the eye of a land animal.

Why are there no openings from the surface directly into the ears? Show the suitability of the fins as organs of locomotion in water.

REFERENCES

Silcox and Stevenson: *Modern Nature Study*

Nash: *Fishes of Ontario* (from Department of Education. free)

Kellogg: *Elementary Zoology*

CHAPTER XII

FORM IV

AUTUMN

GARDEN WORK

The regular work of cultivation of garden and experimental plots should be carefully attended to. Pupils in this Form should be able to do all kinds of garden work with a good deal of proficiency. The work of selecting the best flowers for seed production should be continued. These should be used for planting in the school garden and in home gardens as well. This part of the work might be left to the girls. The boys should be encouraged to take up the systematic selection of seed grain. To get good seed to start with, two methods may be used:

1. Decide upon the kind of grain to be selected and choose from one of the best fields a hundred of the best heads—those that are vigorous, clean, free from rust or smut, and standing up straight. When the heads are dried a little, shell the grain off them and preserve it in a jar in a cold, dry place until spring.

2. Take a quart of oats and pick it carefully, keeping only the largest and most plump kernels. Keep this for spring planting. At the same time, a sample of the poorer grains should be kept for comparison. A regular system of selection should be followed from year to year, taking enough of the largest, brightest, and most compact heads from the plot each autumn to sow a plot of equal size the next spring. After the selection of heads has been made,

the remainder of the crop may be harvested, and the grain from this known as general crop from hand-selected seed of the first, second, third year, etc. If the value per acre is required, the plots should be made of a certain size easy to compute, such as one rod square or one rod by two rods. ($10\frac{1}{2}$ ft. by 21 ft. is about $\frac{1}{200}$ acre.) Samples of each crop should be kept in uniform bottles and labelled; for example—"From selected heads of 1911". The yield per acre in the plot from which the selected heads came should also be noted. These will be interesting for purposes of comparison and for testing duration of vitality later. If the same amount of grain is used in planting a plot each time, the change in bushels per acre may be ascertained and also in pounds per bushel. Some of the boys in this Form may wish to continue this work of improvement by selection and, if so, they should communicate with the Secretary of the Canadian Seed Growers' Association, Canadian Building, Ottawa, and receive full instructions to enable them to carry on their work practically as well as scientifically.

HERBACEOUS PERENNIALS FROM SEED

The teacher should encourage the growing of herbaceous perennials for the purpose of beautifying the school grounds. Many plants may be started from seed at the school and given to the pupils for home planting. These plants require but little attention and provide excellent bloom in gardens and home grounds from early in spring before annuals are in bloom, on into the autumn. A list of the best varieties will be found in Circular 13, on *Elementary Agriculture and Horticulture*, a copy of which should be in every school. The seed plot should be fertilized and prepared in the usual way, and the seeds

planted before the first of September. They may be started in June also, in which case they make more growth before winter. The plot should be well fertilized with thoroughly rotted manure and, if the soil is very dry, the plot should be well watered the day before the seeds are planted. The seeds are usually quite small and should be covered very lightly. The plot should be protected from the hot sun by means of cheese-cloth tacked on a frame. The plants should be watered twice a week in dry weather. In the late autumn, when the ground freezes, the plot should be covered with leaves or straw and some boards, which should be removed when the frost comes out in the spring.

DECIDUOUS TREES

Before the pupils of this Form leave school they should be able to recognize, by name as well as by sight, all of the species of trees found in their vicinity. To this end the teacher should help them to prepare an inventory of species of trees, shrubs, and vines of the vicinity. They should learn to distinguish the different species of maples, elms, birches, etc. A named collection of leaves helps materially in doing this. The influence of environment upon the growth and shape of trees and how trees adapt themselves to the conditions in which they live is a most interesting and profitable study, demanding careful observation, reflection, and judgment.

REFERENCES

Muldrew: *Sylvan Ontario.* Briggs.
Keeler: *Our Native Trees.* Scribners' Sons. $2.00.

TREES IN RELATION TO THEIR ENVIRONMENT

Consider the influences at work and their effect under the following heads:

1. Character of the Soil and Subsoil.—It may be gravelly, pure sand, sandy loam, clay or clay loam, muck or humus, shallow or rocky, and the subsoil may be sand, clay or hard clay with stones (hard-pan). Notice what species are most common in each kind of soil.

2. Water Supply.—What species are found naturally in moist ravines or along the margins of rivers and lakes, in bogs or swamps, on dry, sandy plains, or rocky hillsides. Consider also the rainfall.

3. Exposure to Sunlight.—Account for the lack of symmetry in the shapes of trees. Branches grow only where their leaves can get the light. Account for the pith in many tree stems not being in the geometric centre. Account for the rapid growth in height made by young trees in the woods. Their light supply is chiefly from above, and they stretch up toward it as rapidly as possible. Dim light causes rapid growth at the expense, however, of strength of tissue, but as these young trees are protected in the woods from the strain of wind storms, their slimness and lack of toughness is a benefit rather than a hindrance to them. Also, the limbs near the ground die off while the trees are still young and small, giving us the clear timber tree, free from large knots, tall and straight. Make further application of this principle of light in relation to the planting of trees for shade and for wood or lumber. Account for the large size of the leaves of young trees in the dimly lighted woods as compared with the leaves of older trees. The principle of rapid growth in dim light is seen here also. It will be noticed

that the large leaves of the young trees are more thin, soft, and flexible.

4. Wind.—Observe the tops of tall trees that have always been exposed to a strong prevailing wind as, for instance, those growing on the tops of hills or the eastern shore of a lake which has a prevailing west wind. The tops lean in the direction in which the prevailing wind blows. Does strong wind help or hinder the growth of a tree? Examples of stunted trees on wind swept hills or shores readily show this. It will be seen also that the higher branches are poorest on the side most exposed to the wind.

5. Suitability of the Species to the Climate.—Observe that some trees retain their leaves much later in the autumn than do others. The beech, hickory, red oak, and chestnut are good examples. These are on the northern extreme of their territory of growth. The tree best suited to a rigorous climate is the one that finishes its work early in the autumn and has all its tissues well matured before cold weather sets in. Examples: maple, elm, birch, and willow.

FRUITS

EXCURSION TO A WELL-KEPT ORCHARD

If the teacher can arrange to take the pupils to see a well-kept orchard about the time of the apple harvest, it will help to arouse interest in the study of fruits. The trees, as well as the fruit, frequently show distinguishing marks whereby they may be identified. Have the pupils notice the following points: general shape of tree, colour of bark, shape of leaf, method of cultivation, fertilizing, pruning and grafting, spraying and its need, orchard pests, method of picking and packing apples in barrels and boxes for market.

SMALL FRUITS

Study the method of propagating strawberries and such bush fruits as currants, gooseberries, raspberries, and blackberries. Reports issued from the Fruit Division of the Experimental Farm at Ottawa gives information regarding the best varieties suitable for different parts of Ontario and Quebec. Have the pupils try propagating strawberries by taking the stolons or runners; currants and gooseberries, by means of layers or stem cuttings; and raspberries or blackberries, by root cuttings or the detaching of root shoots or suckers. Stem and root cuttings, when taken in the autumn, may be planted at once or may be stored in damp moss or sand in a cold cellar over winter. Stem cuttings should be about the size and length of a lead-pencil and root cuttings about half that size.

AUTUMN WILD FLOWERS

Observations made with garden flowers should be supplemented by observation lessons on a few selected wild flowers of the woods, fields, and roadsides. Although the spring months afford a much greater variety of wild flowers than do the autumn months, they do not afford quite as good an opportunity for finding and studying them. The woods and fields are drier and more easily reached in the autumn and the fall flowers last much longer. Some of the species seen blooming in spring and early summer are now in fruit and scattering their seed, so that the pupils have a chance to follow out the whole life history of a few chosen species. The pupils in this Form might select for special study the milkweed, wormseed mustard, wild aster, and goldenrod. These should be observed out-of-doors, preferably, but suitable classroom lessons may be taught by using similar matter.

MILKWEED

Taking the milkweed as a type, the following points are to be considered:

The kind of soil, where found, and whether in sun or shade.

Try to pull up a small-sized plant. Dig one up and notice the underground part.

Note the size of the largest plant seen, also the size of the leaves, and how they are arranged to prevent overshadowing.

Break off a leaf and note the white sticky juice, whence the name "milkweed". Discuss this milk as a protection to the plant.

Note time of first and last flowering of the plant and the colour and odour of the flowers. Watch insects gathering honey on a bright day. Note the little sacks of pollen that cling to their feet. They sometimes get their feet caught in little slits in the flower and perish.

After the flowers disappear, note the forming of the little boat-shaped pods in pairs. Select one that is ripe and notice that it bursts along one side which is most protected. Open a pod carefully and notice how beautifully the flat, brown seeds are arranged in overlapping rows and how each seed has a large tuft of silky down that serves to carry it far away in the wind. This silk-like down is sometimes used to stuff cushions, and because of it the plant is sometimes called silk weed.

One species of butterfly in particular feeds upon this plant—the monarch, or milkweed, butterfly. This is one of the few butterflies that birds do not eat. It is protected by a distasteful fluid. Look on the under side of the leaves of several plants until you find a pretty, pale green cocoon with golden dots, hanging by a thread-like

attachment. Early in the season the larvæ may be found feeding on the leaves.

This plant is troublesome in some fields and gardens and so is classed as a weed. When the stems come up in the spring, they are soft and tender and are sometimes used as pot herbs.

CORRELATIONS

Draw a leaf, a flower, a pair of pods, and a seed with its tuft.

Write an account of a visit to the woods to study wild flowers.

TREES

A study of the pines of the locality may be commenced in November, after the deciduous trees have lost their leaves and have entered their quiescent winter period. This is the time when the evergreens stand out prominently on the landscape, in sharp contrast with the other trees that have been stripped of their broad leaves and now look bare and lifeless. If no pines are to be found in the vicinity, cedar or hemlock may be substituted. The lessons should, as far as possible, be observational. The pupils should be encouraged to make observations for themselves out of school. At least one lesson should be conducted out-of-doors, a suitable pine tree having been selected beforehand for the purpose. The following method will serve as a guide in the outdoor study of any species of tree:

THE WHITE PINE

Have the pupils observe the shape and height of the tree from a distance and trace the outline with the finger. Compare the shape of this tree with others near by of the same species and then with members of other species.

Have the pupils describe in what particulars the shapes differ in different trees. They will come to realize that the difference in shape results from differences in length, direction, and arrangement of branches. They may notice that other evergreens resemble the pine in that the stems are all straight and extend as a gradually tapering shaft from the bottom to the top, that all have a more or less conical shape, and that the branches grow straight out from the main stem and not slanting off as in the case of the maples and elms.

Coming close to the tree, the pupils may first examine the trunk. By using a string or tape-line, they may find out how big it is around and the length of the diameter. Tell them how big some evergreens are (the giant trees of the Pacific Coast are sometimes over forty feet around). Have them notice where the trunk is largest, and let them find out why a tree needs to be so strong at the ground. Heavy wind puts a great strain on it just at this point. Illustrate by driving a long slat or lath into the ground firmly; then catching it by the top, push it over, and it will break off just at the ground. If a little pine tree could be taken up, the pupils would be interested in seeing what long, strong, fibrous roots the pine has.

Let them examine the bark of the trunk and describe its colour and roughness. The fissures in the bark, which are caused by the enlarging of the tree through the formation of new wood under the bark, are deeper at the bottom of the tree than at the top—the tree being younger and the bark thinner, the nearer to the top we go. How old is the very top, down to the first whorl of branches? How old is the stem between the first and second whorls? Between the third and fourth? Let the pupils find out in this way the age of a little pine that is regular and unbroken. The

whorls of branches near the ground are usually small and dead in young trees and in old trees have completely disappeared. Relate the size of the trunk to its age, and also relate the size and length of the branches to their age. Where are the youngest branches and how old are they? What branches are oldest? Notice how the branch is noticeably larger just where it joins the trunk, as this is the point of greatest strain. Are the branches the same length on all sides of the trunk? If not, find one where branches are shorter on one side than on the other and try to discover the cause. Usually, if other trees are near enough to shade a certain tree, the branches are shorter and smaller on the shaded side.

Let the pupils look up into the tree from beneath and then go a little distance away and look at it. They will notice how bare the branches are on the inside, and the teacher will probably have to explain why this is so. They will discover that the leaves are nearly all out toward the ends of the branches. The leaves get light there while the centre of the tree top is shaded, and the great question that every tree must try to solve is how to get most light for its leaves. The pupils will now see an additional reason why the lower limbs should be longer than the upper ones. The greater length of the lower limbs brings the leaves out into the sunlight.

Why this tree is called an evergreen may now be considered. Why it retains its leaves all winter is a problem for more advanced classes, but if the question is asked, the teacher may get over the difficulty by explaining to the class that the leaves are so small and yet so hardy that wind and frost and snow do not injure them.

The pupils may each bring a small branch or twig back to the school-room, if the white pine is growing com-

monly about, otherwise the teacher may provide himself with a branch upon which to base another observation lesson in the class-room.

If the tree has cones on it, an effort should be made to get a few, as they will also be considered in a subsequent class-room lesson. If the cones have not yet opened when they are picked, so much the better, as they will soon open in a warm room, and the pupils will be able to examine the seeds and notice how they whirl through the air in falling. If possible, let the pupils have an opportunity of seeing pine trees growing in the woods as well as in the open.

OUTLINE OF A CLASS-ROOM LESSON ON THE WHITE PINE

Inferences. — If possible, each pupil is supplied with a small branch of the white pine and the teacher with a larger branch which can easily be seen by all the pupils. Before proceeding to examine the specimens, give the pupils a chance to tell what they now know about the white pine, and thus review the lesson taken out-of-doors. Then ask a few questions bearing upon their own observations, such as: What was the soil like where you found the pine tree growing? (They are found most commonly on light, sandy soil.) Did you notice any difference between the shapes of the pines in the deep woods and the pines in the open fields? Did you notice any dead limbs on those in the woods? Why did they die? The pupils may conclude that branches whose leaves cannot get the sunlight must die. Show that this causes knots in the lumber and exhibit samples. This explains also why the trees of the forest have such tall stems without branches for a long distance up from the ground. They get the light only from above and seem to strive with the surrounding

trees to reach it. If we want trees to grow tall, how should we plant them? (Close together) What would such trees be good for? (Making timber or lumber) If we want trees to grow low and have thick and bushy tops, how should we plant them? (Far apart) What would such trees be good for? (Their shade and their beauty) Good shade trees should be thirty to forty feet apart.

Ask the pupils if they have ever been near a pine tree when a gentle breeze was blowing, and have them tell the cause of the sound that they heard. They may decide that the shape and size of the leaves caused the sound when the wind was blowing through the tree top. Have them examine the branches in order to discover the following points:

Leaves.—These are in bunches of five, two to three inches long, three-cornered, and with little teeth pointing toward the tip, light green near the tip of the bough (young leaves) and darker further down (older leaves); age of a leaf the same as the age of the wood it grows on, therefore some leaves are one year, some two, and a few three years old. No leaves on four-year-old wood, therefore the leaves fall off the white pine the third year. Ask pupils to try to find out by observation when the leaves fall off the pines. Note the fragrance of the leaves, and that they are sometimes put into "pine" cushions, also, how slippery they are to walk on.

Buds.—These are found at the tips of the branches, one large one in the centre and several smaller ones grouped around it. Note their reddish-brown colour and that they are made up of scales overlapping and covered with gum which keeps out the rain, thus protecting the little growing tip inside. When buds grow, they become little twigs with leaves on. Find where the buds were a year ago.

Notice the light colour of the twigs that grow during the present season and the darker colour of the twigs of the previous year. Where were the buds two years ago? What did the centre bud become? (A continuation of the stem) What did the other buds, called lateral buds, become? (New branches) Compare the growth made in different years.

Notice also how white the wood of the twigs is—the probable reason for calling it "white pine".

CONES.—Note the length and shape of the cones and how the seeds are placed in them inside the large scales. Get some of the seeds and note the wing-like attachment. Take the wing off a seed and drop it from a height at the same instant with one that has its wing attached. Note the whirling motion and infer what purpose the wing serves in scattering seed. Taste the kernel of a pine seed and discover why squirrels are fond of them. Burn a pine cone.

Find out what birds like to live in this tree. What has been noticed about them and their nests?

Have the pupils keep the seeds until the following spring by putting them in a box of dry sand and setting them in a cold place. They should then plant them in a corner where they can be partly shaded when the sun is bright. Plant them about half an inch deep and keep them watered if the weather is dry during the first summer.

NOTE.—The cones drop their seeds from high up in the tree so that the wind can carry the seeds long distances. The cones usually stay on the trees for a couple of years after they lose their seeds.

CORRELATIONS

Draw a pine tree, a bunch of pine needles, a pine cone, and a pine seed.

Write a description of a pine tree seen in the woods; also of one found in the open.

Write a list of things for which the white pine is useful.

To the teacher.—The winter months, besides affording an opportunity for seeing trees and plants in their dormant or quiescent condition, also afford an opportunity for reading and reflection, for recalling observations and experiences of the past season, and for making plans for work and study in the school garden, woods, and fields when spring returns. The knowledge gained by the pupils through first-hand observation of trees, flowers, and gardens can be greatly extended by pictures and stories descriptive of these, which the teacher may from time to time bring to the school-room. Their personal experiences will be the basis for interpretation of many new things which will come up in the reading lessons, in selections which the teacher reads from week to week, and in books and papers which they themselves read in their homes. Thus the interest that is aroused by the first-hand studies of plants in garden, orchard, or woodland will be carried over from autumn to spring, and the pupils, with the awakening of spring, will take up anew the study of plant life with a keener interest because of the time given to reading and reflection during the winter. Illustrated magazines dealing with gardening and with the study of trees and plants, and such magazines as have a children's department, will prove of great assistance to the teacher who makes any serious attempt to interest pupils in plant studies. Stories of life in the woods and of plant studies suitable to young pupils should be used.

REFERENCES

Margaret Morley: *Flowers and their Friends.* Ginn & Co. 50 cents.
Margaret Morley: *Seed Babies.* Ginn & Co. 25 cents.
Margaret Morley: *Little Wanderers.* Ginn & Co. 30 cents.
Alice Lounsberry: *The Garden Book for Young People.* Stokes. $1.50.
Gertrude Stone: *Trees in Prose and Poetry.* Ginn & Co. 45 cents.

COMPARATIVE LESSON ON VARIETIES OF WINTER APPLES

KING, BALDWIN, NORTHERN SPY

Discuss the names, keeping and cooking qualities of the apples, and bearing qualities of the trees.

Provide each member of the class with a typical representative of each of the above varieties of apples.

Compare the three apples as to size, form, colour—including marks; hardness, length, and thickness of stem; depth of cavity at the stem end; depth and shape of the cavity at the calyx end.

Split each apple from stem to calyx and compare as to the thickness and toughness of the skin, the colour of the flesh, the size of the core, taste and juiciness of the flesh.

To the teacher.—All three are apples of fair size, the Baldwin being on the average the smallest of the three. All three are roundish, but the King is somewhat oval-round, and the Spy, conical-round. The Baldwin has a yellowish skin with crimson and red splashes dotted with russet spots. The King is reddish, shading to dark crimson. The Spy has a yellowish-green skin sprinkled with pink and striped with red.

The beautiful colours make all these apples very popular in the markets of American cities and in those of the British Isles; but the soft and easily damaged skin of the Spy makes it the least desirable as an apple for export.

All keep well and in cool cellars remain in good condition until April. They may be kept much longer in cold storage chambers, where the temperature is uniformly near the freezing point of the apple.

The Baldwin apple tree is reasonably hardy within the ordinary range for apple trees, and its yield is a satisfactory average. The King apple tree is not a hardy tree, nor is it a satisfactory bearer except in the best apple districts. The Spy is a fairly hardy tree and thrives and yields well throughout a wide range; but it does not begin to bear until it is about fifteen years old.

A comparative lesson may also be based on selected varieties of autumn apples, such as Fameuse, McIntosh Red, Wealthy, Gravenstein, and St. Lawrence.

CODLING MOTH

Begin the study of the codling moth in August by examining wormy apples. Find out, by asking the pupils, which orchards of the locality had been sprayed in the spring.

Ask the pupils to count out at random one hundred apples and to select from these the number that are wormy. What percentage of the apples are wormy? Compare the percentage of wormy apples in unsprayed, with that in sprayed, orchards. The results will afford evidence of the benefit of spraying.

Find out, if possible, the dates on which, and the conditions under which, the spraying of the orchards with the least number of wormy apples was done.

Ask the pupils to bring to the school-room a number of wormy apples. Have the pupils cut these open and note the nature and position of the hole, or burrow, and the amount of damage done to the apples.

Have the pupils observe the larva and note the size, colour, shape, and number of legs.

To the teacher.—The apple maggot is a less common insect larva and may be distinguished from the larva of the codling moth by the fact that the former has no legs and has the habit of burrowing in all directions through the pulp of the apple, while the larva of the codling moth works almost entirely in the core.

The cocoon and pupa phase of this insect may be obtained by keeping the wormy apples in a box containing loose paper on which the cocoons will be placed, or by searching under the bark scales of apple trees in October.

Describe the cocoons. Open some of them and describe the contents. Keep the remaining cocoons in a box or vivarium in a cool place during the winter.

What birds are seen tapping at the bark scales of the apple trees during winter? Examine the bark scales when a downy woodpecker has been at work and note that the cocoons have been destroyed.

Should we encourage the visits of woodpeckers to the orchards?

By hanging up a beef bone in the orchard, various birds, including woodpeckers, will be induced to visit and perhaps to make their homes in the orchard.

REFERENCES

Common Insects Affecting Fruit Trees, Bulletin No. 158, Department of Agriculture, Parliament Buildings, Toronto.

Bulletins Nos. 158 and 171, Ontario Department of Agriculture, deal with many insect pests and their remedies.

In May look for the adult moths as they emerge from the cocoons. Observe the colour, size, shape, and the bright copper-coloured horse-shoe on the front wing—the "brand" of the codling moth.

Examine the little apples when the blossoms are falling. Note the tiny, flat, oval-shaped egg at various places on the surfaces of the apples and a few days later the tiny worm which emerges from the egg. This soon eats its way into the apple, entering usually at the calyx end. If spraying is done after the petals have fallen and just before the calyx end closes up, a drop of poison is inclosed, and when the larva enters it and begins eating its way into the apple, it gets the poison.

SOME COMMON ANIMAL FORMS

Brief lessons should be given on some of the lower members of the animal kingdom, for the purpose of broadening the interests of the pupils. The following are suggested as types: snail, spider, freshwater mussel (clam), crayfish (crab), centiped, milliped, salamander, and wood-louse.

These are common animal forms, most of which are frequently seen by the pupils, but seldom are their interesting life habits or their places in the animal kingdom recognized. The salamander is to many pupils a lizard of the most poisonous kind; centipeds and millipeds are worms, and they do not recognize that the clam is an animal with sensibilities and instincts.

REFERENCES

Kellogg: *Elementary Zoology*
Silcox and Stevenson: *Modern Nature Study*

CENTIPEDS AND MILLIPEDS

Under stones and sticks in moist soil are to be found two worm-like forms, both having many legs.

One of these animals is flat, about an inch long, brown in colour, and provided with a pair of long feelers. On each division of the body is a single pair of legs. This is the *centiped.* The other animal is more cylindrical in shape and has two pairs of legs on each division of the body. Its colour is a darker brown than that of the centiped, and it has a habit of coiling into a spiral shape, when disturbed, so that the soft under surface is concealed. This is the *milliped.* Both of these animals are quite harmless and feed on decaying vegetable matter. They stand midway between worms and insects in forms and habits.

A brief observation lesson on each animal, involving their movements and the structural features named above, will enable the pupils to identify them and to appreciate their position in the animal kingdom.

SALAMANDERS, OR NEWTS

Some forms of these are found in water, as in streams, ponds, and ditches, while other forms are found on land, where they hide under stones and sticks. They are commonly mistaken for lizards, which they closely resemble in shape; but the two animals may be distinguished by the fact that the surface of the body of a salamander is smooth, while that of a lizard is covered with scales.

The small red or copper-coloured newts are the most common in Ontario and are frequently found on roads after heavy rains. The tiger salamanders are larger than the red newts and are marked with orange and black

spots, hence the name "tiger". Many people believe this species to be especially venomous, while in reality it is quite harmless and, like the other salamanders, is useful for destroying insects and small snails, which form the greater part of its food.

To the teacher.—The superstition of the salamander's power to extinguish a fire into which it is thrown still exists. The early life of the salamander is spent in water, the young form being very much like a tadpole. The salamanders are close relatives of the frogs and toads and may be kept in a jar or vivarium in wet moss or grass. The pupils should learn to recognize the animals and should be instructed as to their habits.

SPIDERS

Problems in observation.—In how many places can you find spiders' webs? How many forms of spiders' webs can you find? Are the many webs that are found on the meadow grass in the dewy mornings the homes of spiders? If so, describe where the spiders live. (At the bottom of tunnels that run into the ground.)

What uses do spiders make of their webs? (Trapping prey, supporting egg cases, protection, and means of moving, as in the case of cobweb spiders.)

Drop a fly upon a spider's web and observe the action of the spider. Search under the webs of spiders in attics and sheds and learn, from the skeletons found there, what the spider feeds upon. It will be found that flies, beetles, and other spiders are killed by this monster.

Watch a spider spinning its web and find out what parts of the body are used in this work. It will be seen that the threads are produced from little tubes at the rear

end of the animal and are placed and fastened by means of the feet.

Examine, by the aid of a hand lens, the feet and head of the spider. Note the "brushes and combs" on the former. Note, on the latter, the four, six, or eight eyes (the number and arrangement vary), and the short poison claws at the front of the head. How are the poison claws adapted for seizing and piercing? Note the sharp hooks at the lower ends.

BIRD STUDIES

Continue the lessons in bird identification and in bird types, using the methods outlined for these studies in Form III. (See pp. 217-24.)

CHAPTER XIII

FORM IV

WINTER

FOREST TREES

EVERGREENS

SEVERAL species of evergreens have already been studied. These should be reviewed, and representatives of other species examined. Mid-winter is most suitable for the study of evergreens. The following points should be considered:

1. Description leading to identification
2. Nature of soil and water conditions
3. Common uses of each species of evergreen
4. Collection of wood specimens and cones.

WOOD SPECIMENS

Specimens should be uniform in size and should show bark on one side and heart wood as well as the outside, or sap wood. They should be about six inches long, two inches wide on the side having the bark, and should gradually come to an edge toward the pith, or centre. When seasoned, one side and one edge should be polished and then oiled or varnished. Specimens of the wood of the deciduous trees may also be prepared during the winter.

FRUITS

During the winter months, some time should be devoted to reading and discussing articles on general farming and fruit growing. Such articles may be taken from books, magazines, or newspapers, and may be supplied partly by the teacher and partly by the pupils. These articles will be appreciated by the pupils all the more because of their studies of fruit trees during the season. Such topics as the following may be discussed:

1. Best kind of apples, plums, bush fruits, and strawberries. Reports from the Dominion and Provincial Departments of Agriculture.

2. Method of raising fruit trees—from seed, grafting, and budding.

3. Demonstrations in pruning. This may be done in early spring by taking a class to a neighbouring orchard.

4. Methods of planting and cultivation.

5. Packing and storing.

6. Spraying. Much information is to be found in Horticultural Journals and papers, and in Bulletins to be obtained from the Secretary of Agriculture for Ontario.

Illustrated articles on gardening and fruit growing should be collected for school use. Views of fine gardens, parks, and home grounds will be of interest to the pupils. Simple artistic methods of ornamental planting with trees, shrubs, vines, and herbaceous perennials can now be introduced, and some scheme for improving the school grounds outlined.

Catalogues should be obtained soon after New Year's and, after examining their merits, the best varieties of seed and fruit for the district should be selected. Horti-

cultural societies, as well as Dominion and Provincial Departments of Agriculture, commonly give selected lists with descriptions of the different varieties.

WEEDS AND WEED SEEDS

The training in the observation and identification of weeds and weed seeds, which was begun in Form III, should be continued in Form IV. For method see Form III.

PHYSICAL SCIENCE PHASE OF NATURE STUDY

WATER PRESSURE

1. Grasp an empty tin can by the top and push it down into a pail of water. Note the tendency of the can to rise. The water presses upward. Its downward pressure is evident.

2. Tie a large stone to a string, hold it at arm's length, shut the eyes, and lower the stone into water. Note the decrease in weight. This is also due to upward pressure, which we call buoyancy. The actual decrease may be found by means of a spring balance.

3. Try Experiment 2, using a piece of iron the same weight as the stone. Is the decrease in weight as evident? Ships made wholly of iron will sink. Explain.

4. Put an egg into water; it slowly sinks. Add salt to the water; the egg floats.

EXERCISES

1. Will the human body sink in water? In which is there less danger of drowning, lake or sea water?

2. When in bathing, immerse nearly the whole body, then take a full inspiration. Note the rise of the body.

3. Why does ice float? (See expansion of water by freezing.)

4. Balloons are bags filled with some light gas, generally hydrogen or hot air. They are pushed up by the buoyancy of the air. The rise of heated air or water (see Convection) is really due to the same force. Clouds, feathers, and thistledown are kept in the air more by the action of winds and small air currents than by buoyancy.

STUDY OF AIR

(Consult *Science of Common Life*, Chaps. VIII, IX, X.)

1. Air takes up space. Put a cork with one hole into the neck of a flask or bottle. Insert the stem of a funnel and try to pour in water. Try with two holes in the cork. When we call a bottle "empty" what is in it?

2. Air is all around us. Feel it; wave the hands through it; run through it; note that the wind is air; inhale the air and watch the chest.

3. Air has weight. This is not easy to demonstrate without an air-pump and a fairly delicate balance.

Fit a large glass flask with a tightly fitting rubber stopper having a short glass tube passing through it. To the glass tube attach a short rubber one and on this put a clamp. Open the clamp and suck out all the air possible. Close the clamp and weigh the flask. When perfectly balanced, open the clamp and let the air enter again. Note the increase in weight.

If an air-pump is available, procure a glass globe provided with a stop-cock (see Apparatus). Pump some of the air from the globe, then weigh and, while it is on the balance, admit the air again and note increase in weight.

Tie a piece of thin sheet rubber over the large end of a thistle tube; suck the air out of the tube and note how the rubber is pushed in. This is due to the weight or pressure of the air. Turn the tube in various positions to show that the pressure comes from all directions. To show that "suction" is not a force, let a pupil try to suck water out of a flask when there is only one opening through the stopper. If two holes are made, the water may be sucked up, that is, *pushed* up by the weight of the air.

Fill a pickle jar with water. Place a piece of writing paper on the top and then, holding the paper with the palm of the hand, invert the jar. The pressure of the air keeps the water in.

A cubic foot of air weighs nearly $1\frac{1}{4}$ oz. Find the weight of the air in your school-room.

The atmosphere exerts about fifteen pounds pressure on every square inch of the surface it rests against. Find the weight supported by the top of a desk 18 inches by 24 inches. If the surface of the body is eight square feet, what weight does it have to sustain? Why does this weight not crush us?

THE BAROMETER

The experiments immediately preceding will have paved the way for a study of the barometer.

1. Fill a jar with water and invert it, keeping its mouth below the surface of the water in another vessel. If the pupils can be led to see that the water is sustained in the jar by the air pressing on the water in the vessel, they can understand the barometer.

2. Fill a tube about 30 inches long, and $\frac{1}{4}$ inch inside diameter with water, and invert it over water, as with the jar in the previous experiment.

3. Use the same tube or one similar to that in 2 above, but fill with mercury and allow the pupils to notice the great weight of the mercury. Holding the mercury in with your finger, invert the tube over mercury. This time the fluid falls some distance in the tube as soon as the finger is removed. A tube of this size requires 1 lb. of mercury.

Lead the pupils to see that the mercury remaining in the tube is sustained by the air pressure, and that any increase or decrease of the atmospheric pressure will result in the rise or fall of the mercury column. Leave the barometer (made as in 3 above) in the room for a few days and note whether its weight changes. The use of the instrument in predicting weather changes should be emphasized. Compare your barometer with the records in the daily papers.

The average height of the barometric column is 30 inches at sea-level. Explain how you could estimate heights of mountains and balloons with a barometer.

THE COMMON PUMP

This is a valuable application of air pressure. A glass model will prove useful, but a model made by pupils will be much more so. (See *Laboratory Exercises in Physics* by Newman.)

The water rises in the pump because the sucker lifts the air from the water inside, allowing the air outside to push the water up. A common pump will not lift water more than about 30 feet. Why is this? Compare the pump to a barometer. (See *The Ontario High School Physics.*)

EXPANSIVE FORCE OF AIR

Air and all other gases manifest a pressure in all directions not due to their weight. The power of air to keep

tires and footballs inflated and that of steam in driving an engine are examples. It is this force that prevents the pressure of air from crushing in, since there are many air spaces distributed throughout the body.

COMPOSITION OF AIR

This subject and the three immediately following it have a special bearing on hygiene.

1. Invert a sealing-jar over a lighted candle. Has the candle used up *all* the air when it goes out?

2. Place a very short candle on a thin piece of cork afloat on water in a plate; light the candle, and again invert the jar over it. Note that the candle goes out and the water rises only a short distance in the jar; therefore *all* the air has not been used up.

3. Slip the glass top of the jar under the open end and set the jar mouth upward on the table without allowing any water to escape. Now plunge a lighted splinter into the jar. The flame is extinguished.

Air, therefore, contains an active part that helps the candle to burn and an inactive part that extinguishes flame. The names *oxygen* and *nitrogen* may be given. These gases occur in air in the proportion of about 1·4. (This method is not above criticism. Its advantage for young pupils lies in its simplicity.)

OXYGEN

Make two or three jars of oxygen, using potassium chlorate and manganese dioxide. (See any Chemistry text-book.) Let the pupils examine the chemicals, learn their names, and know where to obtain them. Perform the following experiments:

1. A glowing splinter relights and burns very brightly if plunged into oxygen.

2. A piece of picture wire tipped with sulphur burns with great brightness.

3. Burn phosphorus or match heads in a spoon. A spoon may be made by attaching to a wire a bit of crayon having a hollow scooped on its upper surface. A clay pipe bowl attached to a wire will answer.

From these experiments pupils will learn the value of nitrogen as a diluent of the oxygen. Pure oxygen entering the lungs would be just as destructive as it would be entering the furnace.

CARBON DIOXIDE

1. Make a jar of this gas. Washing soda and vinegar will answer if hydrochloric acid and marble are not obtainable. (Consult the *Science of Common Life,* Chap. XIII, and any Chemistry text-book.)

2. Lower a lighted candle first into a jar of air then into the jar of carbon dioxide.

3. Make some lime-water by stirring slaked lime with water and allowing the mixture to settle. Shake up some clear lime-water with a jar of the gas. Pupils will be made to understand that the milky colour will in future be considered the test for carbon dioxide.

4. Have one of the pupils cause his breath to bubble through some clear lime-water for a minute. Using a bicycle pump, cause some fresh air to bubble through lime-water.

5. Hold a clear jar inverted over the candle flame for a few seconds, then test with lime-water.

6. Invert a large jar over a leafy plant for a day. Keep in the dark and test the jar with lime-water.

Is this gas likely to be in the air? Set a plate of lime-water in the school-room for a day or two, and then examine it. Try to pour the gas from jar to jar and use a candle as a test. Is the gas heavier than air?

On account of its weight, the gas often collects in the bottoms of old wells, mines, and tunnels. It is dangerous there since it will not support life.

USES:

1. Add a little water to some baking powder and cause the gas that forms to pass through lime-water. What causes the biscuits to "rise"?

2. Mix flour and water in a jar, add a bit of yeast cake and a little sugar, and let stand in a warm place. Test the gas that forms, for carbon dioxide. What causes bread to rise?

3. Uncork a bottle of ginger ale, shake the bottle, and lead the gas that comes off through lime-water.

4. Most portable fire extinguishers depend on the generation of carbon dioxide.

Show the similarity between our bodies and the candle. The candle needs oxygen; it produces heat, and yields water and carbon dioxide. Much of our food is somewhat similar in composition to the wax of a candle; we breathe oxygen, our bodies are warmed by a real burning within, and we exhale water and carbon dioxide.

After exercise why do we feel more hungry? Why do we breathe faster? Why do we feel warmer? Why does the fire burn better when the damper is opened?

IMPURITIES OF AIR

All air contains carbon dioxide. If the amount exceeds 6 parts in 10,000, it becomes an impurity, not so

much on its own account as because it indicates a poisoned state of the air in a room, since organic poisons always accompany it when it is emitted from the lungs.

Other impurities of the air, dependent on the locality and the season, are smoke, dust, disease germs, sewer gas, coal-gas, pollen dust.

SOLUTIONS OF SOLIDS

(Consult the *Science of Common Life*, Chap. VII.)

Have the pupils weigh out equal quantities of sugar, salt, soda, alum, blue-vitriol. Shake up with equal quantities of water to compare solubilities. Repeat, using hot water. Is it possible to recover the substance dissolved? Set out solutions on the table to evaporate, or evaporate them rapidly over a stove or spirit-lamp. Try to dissolve sand, sulphur, charcoal, in water. Obtain crystals of iodine and show how much better, in some cases, alcohol is as a solvent than is water.

APPLICATIONS:

1. Most of our "essences", "tinctures", and "spirits" are alcoholic solutions.

2. Digestion is the effort of the body to dissolve food.

3. The food in the soil enters the plant only after solution.

4. The solvent power of water makes it so valuable for washing.

5. Maple sap is water containing sugar in solution.

6. In the salt region along Lake Huron, holes are drilled to the salt beds, water is poured in, then pumped out and evaporated. Explain.

7. Meat broth is a solution of certain materials in the meat.

8. How could you manufacture salt from sea water?

SOLUTION OF LIQUIDS

Try to mix oil and water, benzine and water, oil and benzine. Only in the third case do we find a permanent mixture, or solution. Try to dissolve vinegar, glycerine, alcohol, mercury, with water.

APPLICATIONS:

1. Paint is mixed with oil so that the rain will not wash it off so easily.

2. Water will not wash grease stains. Benzine is necessary.

3. Why is it necessary to "shake" the bottle before taking medicine?

SOLUTION OF GASES

Study air dissolved in water, by gently heating water in a test-tube and observing the bubbles of air that gather on the inner surface of the test-tube. Aquatic animals, such as fish, clams, crayfish, crabs, subsist on this dissolved air.

LIMESTONE

Pieces of this rock may be found in all localities. Teach pupils to recognize it by its gray colour, its effervescence with acid, and the fossils and strata that show in most cases. If exposed limestone rocks are near, visit them with the pupils and note the layers, fossils, and evidences of sea action. Compare lime with limestone as to touch, colour, and action on water and litmus. Try to make lime by putting a lump of limestone in the coals for some time; add water to this. Other forms of limestone are marble, chalk, egg-shells, clam-shells, scales in tea-kettles.

Geographically, the study of limestone is of great importance. Grind some limestone very fine, add a very

little of this to water, and bubble carbon dioxide through for some time; note the disappearance of the limestone. This explains how limestone rocks are being slowly worn away and why the water of rivers, springs, and wells is so often "hard".

Catch some rain-water in the open and test it for hardness. It will be found "soft". Place a few limestone pebbles in a tumbler with this soft water and after a day or two test again. The water will be "hard".

Compare, as to hardness, the water from a concrete cistern with that from a wooden one.

CARBON

Procure specimens of hard and soft coal, coke, charcoal, graphite, peat, and petroleum. Note the distinctive characteristics of each. Discuss the uses. Try to set each on fire. Note which burns with a flame when laid on the coals or placed over the spirit-lamp. Put a bit of soft coal into a small test-tube; heat and light the gas that is produced. This gas, when purified, is one kind of illuminating gas. Note the *coke* left in the test-tube.

Fill the bowl of a clay pipe with soft coal and seal it up with plaster of paris. After this has hardened, place the bowl in hot coals or in the flame of a spirit-lamp and light the coal-gas at the end of the stem. After all the gas has been driven off, look for the coke inside.

Heat a bit of wood in a small test-tube and light the gas that is evolved. Note the charcoal left.

Cover a piece of wood with sand or earth; heat, and note that charcoal is formed. This illustrates the old method of charcoal-burning. This subject is closely related to industrial geography.

HYDROGEN

A convenient way to prepare hydrogen is to use zinc and hydrochloric acid with a test-tube for a generator. (Consult any Chemistry text-book.) Make the gas and burn it at the end of a tube, holding a dry, cold tumbler inverted over the flame. Note that water is formed. Conclude what water consists of, namely, oxygen and hydrogen. Water may be decomposed into oxygen and hydrogen, hence a use of hydrogen may be shown by attaching a clay pipe to the generator and filling soap bubbles with the gas. When freed these rise quickly.

MAGNETS

If bar magnets cannot be obtained, use a child's horseshoe magnet.

Procure small pieces of cork, wood, iron, brass, glass, lead, etc., and let pupils discover which the magnet attracts.

Have pupils interpose paper, wood, slate, glass, iron, lead, etc., in sheets between the magnet and the iron and note the effect on the force exerted.

Note that when one end of a magnet touches or comes near the end of a nail, the nail becomes a magnet, but not a permanent one.

Magnetize a needle by drawing one of the poles of the magnet from end to end of the needle, always in the same direction, about twenty times. Suspend the needle horizontally with a piece of silk thread and note its position when at rest.

Get a small compass and show how it is related to the foregoing experiments. Emphasize its use to mariners. If possible, get a piece of lodestone and show its magnetic properties.

ELECTRICITY

Half fill a tumbler with water and add about a teaspoonful of sulphuric acid. Set in this a piece of copper and a piece of zinc, but do not let them touch. Make a coil by winding insulated wire around a block of wood about ten times. Remove the wood and place a compass in the centre of the coil. Join the ends of the wire to the two metals in the tumbler. The sudden movement of the needle will be taken as the indication of a current.

Let pupils try experiments with many pairs of solids, such as lead and silver, carbon and glass, wood and iron, tin and zinc, and liquids such as vinegar and brine.

Show pupils how to make a simple battery. See home-made apparatus, page 50, and consult *Laboratory Exercises* by Newman. Two or three dry cells will be found sufficient for any experiments, but the home-made battery is to be preferred.

Show pupils how to make a magnet by winding a piece of insulated wire around a nail and joining the ends of the wire to the battery. Make a horse-shoe magnet by bending the nail and winding the wire about both ends in opposite directions.

As an application of the electro-magnet, show pupils how to make a telegraph sounder. (See Manual on *Manual Training.*) If possible, examine the construction of an electric bell. The motor and electric light are other common applications of the current. Take up the uses of the motor in factories, and for running street-cars and automobiles. Show the necessity for a water-wheel or engine to produce the current, and for wires to connect. Explain that batteries are not used to produce large currents, but that machines called dynamos, similar to motors,

when driven by steam or water-power, will yield electric currents as batteries do.

STEAM

The power of steam may be shown by loosely corking a flask and boiling the water in it until the cork is driven out, or by stopping the spout of a boiling tea-kettle, or by letting a stream of steam impinge on a toy paper wheel. Encourage pupils to learn all they can about steam and gasolene engines and their uses.

FARM TOOLS

This topic should be dealt with only in so far as it can be made a subject for actual observation by the pupils. Children should learn to be thoughtful and observant and to do all kinds of work, manual as well as mental, intelligently.

MACHINES

(Consult *The Ontario High School Physics*, Chap. IX.)

Lever.—When a *lever* is used to lift a log, one end is placed under the log, a block called a *fulcrum* is placed under the lever as close as possible to the log, and then the workman pulls down on the outer end of the lever. For example, if the fulcrum is one foot from the log and ten feet from the man, the latter can raise ten pounds with a pull of one pound, but he has to move his end of the lever ten times as far as the log rises. Try it. See other examples in plough handles, see-saw, balance, scissors, wheel-barrow, pump-handle, handspike, crowbar, canthook, nut-crackers.

Rope and Pulley.—In the *rope* and *pulley* note that when the pulley is a fixed one, the only advantage is a

changed direction of the rope. When the pulley is *movable,* the horse pulling will have only half the weight to draw if the pulley is single, one quarter if double, one sixth if triple, etc. Thus in the case of a common hay-fork the horse draws only half the weight of the hay, but he walks twice as far as the hay moves.

Cogs.—If one wheel has eighty *cogs* and the other ten, the latter will turn eight times to the former's once.

Belt.—When a *belt* runs over two wheels, one having, say, one fifth of the diameter of the other, the smaller will revolve five times for one revolution of the other.

Crank.—With a *crank* two feet long, one may turn a wheel twice as easily as with one one foot long, but the hand will move twice as far. If a wedge is two inches thick at the large end and ten inches long, a man may lift 1000 pounds by striking the wedge a 200-lb. blow.

Inclined plane.—If a plank twelve inches long has one end on the ground and the other on a cart four inches high, one man can roll up the plank the same weight that would require three men to lift, but he has to move the object three times as far.

PROBLEMS

1. Why is a long-handled spade easier to dig with than a short-handled one?

2. Which is easier, to dig when the spade is thrust full length or half length into the earth?

3. Can a small boy "teeter" on a board against a big boy? How?

4. In helping to move a wagon, why grasp the wheel near its rim?

5. In making a balance, why should the arms be equal? In a balance with unequal arms, compare the weights used with the article weighed.

6. In using shears, is it better to place the object you wish to cut near the handles or near the points?

7. Where is the best place to put the load on a wheelbarrow?

8. Notice how three horses are hitched to a plough or binder.

9. Where would you grasp the pump-handle when you wish to pump (1) easily, (2) quickly?

10. Stretch out your arm and see whether you can hold as heavy a weight on your hand as on your elbow.

11. Count the pulleys used in a hay-fork and determine the use of each.

12. If a ton of hay is unloaded at five equal forkfuls, what weight has the horse to draw at each load?

13. Count the cogs on the wheels of a fanning-mill, washing-machine, apple-parer, or egg-beater, and determine how the direction or rate of the motion is changed thereby.

14. Measure the diameter of the large fly-wheel of a thrashing-machine engine, and of that which turns the cylinder in the separator. Decide how many times the cylinder revolves for one turn of the fly-wheel.

15. Think of all the uses of a wedge. Draw one. Compare the axe, knife, and chisel with the wedge.

16. How are heavy logs loaded on a sleigh or truck? How are barrels of salt and sugar loaded and unloaded?

17. There are two hills of the same height. One has a gradual slope, the other a steep one. Which is easier to climb? In what case is it farthest to the top?

18. Why does a cow or horse take a zigzag path when climbing a steep hill?

CHAPTER XIV

FORM IV

SPRING

METHODS OF IMPROVING HOME AND SCHOOL GROUNDS

THE study of plants should lead to an intelligent appreciation of their beauties and a desire to have them growing about. Many of our native trees, shrubs, vines, and herbaceous plants are quite as beautiful as some that are procured at considerable expense from nurserymen. A great work remains to be done in cultivating and popularizing our best native species. Up to this point the pupils have been getting acquainted with them in their own natural habitat; the next step should be to use them in covering up harsh and offensive views about the school and home grounds, in softening and giving restful relief to barren yards and bare walls, to ugly fences and uninteresting walks and driveways.

Begin to plan some simple improvements for the spring. These may be repairing of fences and gates in order to protect the grounds from stray animals, the cleaning up of the yards, the gathering of stones which may be used in making a rockery, the planting of trees along the sides and front of the grounds—a double row of evergreens to overcome a cold northern exposure or to exclude from view disagreeable features, the laying out of a walk or drive with borders, flower beds, or shrubs in little clumps.

Plans of grounds well laid out should be examined and discussed in the school-room. Many illustrated magazines give useful suggestions. Plans can be worked out on the black-board with the pupils. It will take years to complete such a plan, but the pupils should have a part in making the plan as well as in carrying it out. The aim should be to encourage the use of simple and inexpensive things obtained in the vicinity, wherewith to produce harmony and pleasing natural effects.

Comfort and utility must be considered as well as beauty and natural design. In the school grounds the outdoor games must also be provided for and sufficient room allowed.

Such efforts on the part of the teacher and pupils, if wisely directed, are sure to meet with the approval of the parents and must call forth the hearty co-operation of the trustees.

It is not well to attempt too much in one year. It is better to do a small amount well than to leave much work in a half-done condition.

MAKING AND CARE OF A LAWN

The soil must be drained and not too much shaded by trees. At first it should be summer fallowed or cultivated every few weeks throughout the summer, to kill the weeds and make it fine and level. A thick seeding of lawn grass-seed should be sown early the next spring and raked lightly in. All levelling and preparation must have been done the previous season.

Coarse grasses, such as timothy, should not be used on a lawn. Red top and Kentucky blue-grass in equal parts are best and, if white clover is desired, add about half as much white Dutch clover seed as red top. If the soil

has been prepared as above, there is no need to use a foster crop of oats or barley, as is done in seeding down meadows. Roll the lawn after seeding and also after heavy rains as soon as the surface dries. Shortly after the grass appears, begin to run the lawn-mower over it, so as to cut weeds or native grasses that may be gaining a foothold. Watering is dangerous, unless carefully and regularly done during the summer, the evening being the best time. Merely wetting the surface by sprinkling encourages shallow rooting and therefore rapid drying out. Regular mowing and rolling are more important.

REFERENCES

Parsons: *How to Plan the Home Grounds.* Doubleday. $1.00
Waugh: *The Landscape Beautiful.* Judd. $2.00
Department of Education: *Improvement of School Grounds*

SOIL STUDIES

WEIGHT

Using a balance, compare weights of equal-sized boxes of different soils, dried and powdered fine. Note the comparative lightness of humus. Weigh a box of earth taken fresh from the field, from this compute (1) the weight of a cubic foot of such soil, (2) the weight of the soil to the depth of a foot in a ten-acre field.

Repeat the experiment, making it an exercise in percentage.

Fill two glass tubes (lamp chimneys will do), one with finely powdered clay, the other with sand. Set the tubes in a pan containing water. Note the rise of the water due to capillarity. Through which soil does it rise faster? Farther? Try with other soils. Try with fine soil and also with the same soil in a lumpy condition.

From this give a reason (1) for tilling soil, (2) for rolling after seeding.

SUBSOILS

Procure samples of soil from different depths, four inches, eight inches, twelve inches, sixteen inches, etc. Note how the soil changes in colour and texture. In which do plants succeed best? In most fields the richest part of the soil is contained in the upper nine inches; the portion below this is called subsoil. This extends to the underlying rock and is usually distinguished from the upper portion by its lighter colour, poorer texture, and smaller supply of available plant food. The difference is due largely to the absence of humus. The character of the subsoil has an important bearing on the condition of the upper soil. A layer of sand or gravel a few feet below the surface provides natural drainage, but if it be too deep, it may allow the water to run away rapidly, carrying the plant food down below the roots of the plants. A hard clay subsoil will render the top too wet in rainy weather and too dry in droughts, because of the small amount of water absorbed. Such a soil is benefited by under-draining. A deep and absorptive subsoil returns water to the surface, by capillary action, as it is needed. The subsoil finally contains a large amount of plant food, which becomes gradually changed into a form in which plants can make use of it. Pupils should find out the character of the subsoil in their various fields at home and its effect on the fertility of the field.

FERTILIZERS

Along with water, the roots take up from the soil various substances that are essential to their healthy growth. Potash, phosphoric acid, nitrogen, calcium, sul-

phur, magnesium, and iron are needed by plants, but the first three are particularly important. If land is to yield good crops year after year, it must be fertilized, that is, there must be added chemicals containing the above-mentioned plant foods. Land becomes poor from two causes: the plant food in the soil becomes exhausted, and poisonous excretions from the roots of one year's crops act injuriously on those of the next season. Rotating crops will improve both conditions for a while, but eventually the soil will require treatment.

Humus contains plant food and is also an excellent absorbent of the poisonous excretions. It is added as barnyard manure, leaves, or as a green crop ploughed in.

The chemicals commonly used comprise nitrate of soda, bone meal, sulphate of potash, chloride of potash, lime, ashes, cotton-seed meal, dried blood, super-phosphate, rock phosphate, and basic clay.

EXPERIMENTS:

1. Sow wheat on the same plot year after year and note the result when no fertilizer is used. Sow wheat on another plot, but use good manure.

2. Try the various commercial fertilizers on the school plots, leaving some without treatment.

3. Examine the roots of clover, peas, or beans, and look for nodules. These show the presence of bacteria, which convert the atmospheric nitrogen into a form in which the plants can use it. Scientific farmers have learned the value of inoculating their soil with these germs. A crop of peas or clover may produce the same result.

4. Observe Nature's method of supplying soil with humus.

SOIL-FORMING AGENTS

There was once a time when the surface of the earth was bare rock. Much of this rock still exists and in many places lies on the surface, but it is usually hidden by a layer of soil. Soil is said to be "rock ground to meal by Nature's millstones". The process is very slow, but it is constantly going on. The pupils should be directed to find evidences of this "grinding".

1. Running water.—Brooks, creeks, rain, and the tiny streamlets on the hills all tell us how soil is carried from place to place. Get some muddy water from the river after a heavy rain. Let it settle in a tall jar and observe the fine layer formed.

Wash some pebbles clean, place them in a glass jar with some clear water, and roll or shake the jar about for a few minutes. Note that the water becomes turbid with fine material worn from the stones. A process similar to this is constantly going on in rivers, lakes, and seas. Account for the presence of gravel beds now situated far away from any water.

2. Ice Glaciers.—How do these act on rocks? Show evidences in Ontario as far as these can be illustrated from the surroundings, such as polished rocks, boulders, beds of clay, sand, or gravel, small lakes, grooved stones, etc.

3. Frost and Heat.—See "Expansion of Solids", pages 189, 190. Look for splintered or cracked stones. Why do farmers plough in the fall?

4. Wind.—In sections near the lakes the action of the wind in moving the sand may be seen and appreciated. There are other places where this work is going on on a smaller scale.

5. Plants.—Our study of humus shows the value of vegetable matter in soil. Besides contributing to the soil, plants break up rocks with their roots and dissolve them with acid excretions. It is interesting to study how a bare rock becomes covered with soil. First come the lichens which need no soil; on the remains of these the mosses grow. The roots of mosses and lichens help to disintegrate the rock with their excretions, so that, with frost, heat, air, and rain to assist, there is a layer of soil gradually formed on which larger plants can live. A forest develops. The trees supply shade from the sun and shelter from the wind, thus retarding evaporation. The roots of the trees hold the soil from being washed away. The dead leaves and fallen stems provide humus, and, on account of the water-holding capacity of humus, the forest floor acts like a sponge, preventing floods in wet seasons and droughts in dry times.

6. Animals.—Pupils should make a list of all burrowing animals and look for examples. The work of the earthworms is especially interesting. By eating the soil, they improve its texture and expose it to the air. Their holes admit air and water to the soil. The worms also drag leaves, sticks, and grass into their holes and thus add to the humus.

Darwin estimated that the earthworms in England passed over ten tons of soil an acre through their bodies annually. This is left on the surface and makes a rich top-dressing.

TILLING THE SOIL

1. It makes the soil finer, thus increasing the surface for holding film water and enabling it to conduct more water by capillarity.

2. It saves water from evaporation. (See Experiments 7 and 8, Form III.)

3. It aerates the soil, enabling roots to thrive better.

4. It drains (hence warms) the soil, assuring more rapid growth.

5. It kills weeds.

A large part of the work with soils may be done in connection with the garden studies, though most of the above mentioned experiments may be tried in the schoolroom. In ungraded schools any of the experiments may be made instructive to all the Forms.

Pupils should be asked to acquaint themselves with the common implements used on the farm. They should ascertain the special service rendered by each. See *Circular 156,* Dominion Department of Agriculture.

GARDEN WORK

The work in gardening for Form IV should be connected with some definite line of experimental work. The garden should be so planned that a part of it can be used exclusively for experimental work. Co-operation with the Farmer's Experimental Union of the Ontario Agricultural College at Guelph is advisable at this point. The following list of experiments is suggested as suitable for boys especially, but no pupil should attempt more than one experiment each year.

EXPERIMENTS IN PLOTS OUT-OF-DOORS

Experimental plots may be of different sizes, according to the space available, from a yard square to a rod square or larger. A plot 10 ft. 5 in. by 20 ft. 10 in. is almost $\frac{1}{200}$ of an acre, so that the actual yield on such a

plot when multiplied by 200 is an approximation of the yield an acre.

1. Testing of varieties of grains, vegetables, or root seeds, including potatoes new to the district.

2. Testing different varieties of clovers and fodder grasses. These plots should be so situated that they can remain for three years.

3. Thick and thin sowing of grain: Use plots not less than four feet square. They may be tried most easily with wheat, oats, or barley, although any species of grain may be used. Use four plots of the same size, equal in fertility and other soil conditions. In No. 1 put grains of wheat or oats, as the case may be, two inches apart each way. In No. 2 put the grains two inches apart in the row and the rows four inches apart. In No. 3 put the grains four inches apart in the row and the rows four inches apart. In No. 4 put the grains four inches apart in the row and the rows eight inches apart.

If possible, weigh the straw and grain when cut and the grain alone when dry and shelled out of the heads.

4. Deep and shallow growing of grain: Use four plots similar to those in experiment No. 3. Put the same amount of seed in the different plots. In No. 1, one inch deep; in No. 2, two inches deep; in No. 3, four inches deep, and in No. 4, six inches deep. Note which is up first, and which gives the best yield and best quality.

5. Early and late sowing: Three plots are required. Plant the same amount of seed in each and cover to the same depth. Plant No. 1 as early as the soil can be made ready; No. 2, two weeks later; and No. 3, two weeks later than No. 2. Compare the quality and the yield.

6. Effect of sowing clover with grain the first year: Only two plots are required. Sow the same amount of

wheat or oats on each plot. On one plot put a moderate supply of red clover and none on the other. Weigh (or estimate), as in Experiment 3 above, the straw and the grain produced on each,

7. Effect of a clover crop on the grain crop succeeding it the following year: The same two plots must be used as in No. 6. When the grain was cut the previous autumn, the plots should have been left standing without cultivation until spring. When the clover has made some growth, spade it down and prepare the other plot in the same way. Rake them level and sow the same amount of grain in each again. Weigh the crops produced on each.

8. Test quality, yield, and time of maturity of several varieties of the same species. Samples of such varieties of wheat as Red Fife, White Fife, Preston, Turkey Red, Dawson's Golden Chaff, White Russian, etc., may be obtained from the Central Experimental Farm at Ottawa, if not available in the district.

9. Effect of different fertilizers (1) on the same crop, (2) on different crops: This can be done either out-of-doors in small plots or indoors, using pots or boxes.

(1) Effect on the same crop: For example, oats on plots four feet square. The following standard fertilizers may be used: stable manure, nitrate of soda, muriate of potash, and bone meal.

On plot No. 1, a dressing of stable manure,

On plot No. 2, four oz. nitrate of soda,

On plot No. 3, four oz. muriate of potash,

On plot No. 4, eight oz. bone meal,

On plot No. 5, two oz. nitrate of soda, two oz. muriate of potash, and four oz. bone meal.

On plot No. 6, use no fertilizer. Record results.

(2) Effect on different crops: Try a series of experiments similar to the above, using (*a*) peas instead of oats, (*b*) using corn, (*c*) using cabbage, (*d*) using potatoes.

FUNCTION OF PARTS OF PLANTS

This may be introduced in Form III and continued in the next Form. Already the attention of the pupils has been directed to the essential organs of the flower, namely, stamens and pistil. They have noticed the two kinds of flowers on pumpkins, corn, and many trees. They have seen that only the pistillate flowers produce fruit and seeds, and that when the staminate flowers have shed their pollen, they die. They have seen the yellow dust that the stamens contain and have seen bees laden with it as they emerge from the heart of the flower. Have them watch the bee as it enters the flower and notice how it invariably rubs some part of its pollen-covered body against the pistil. When on the moist, sticky top of the pistil, these little pollen-grains soon begin to grow, sending a delicate tube down to the bottom of the pistil to the ovary. Inside the ovary are little bodies called the ovules that are moistened by a fluid that comes from this delicate pollen tube, and at once they begin to enlarge and eventually become the seeds. The coverings surrounding them complete the true fruit.

The use of the root in supporting the plant in its normal position is apparent to every pupil. To demonstrate the firm hold it has upon the soil, have the pupils try to pull up some large plants by the roots. They will then notice the branching roots of some plants and the long conical roots of others. Compare the colour and other surface features of the root and stem. To prove its feeding power, try two plants of equal size, taking the root

off one and leaving it uninjured in the other. Set them side by side in moist earth and notice which withers. Take all the leaves off a plant and keep them off for a few weeks. The plant dies if its leaves are not allowed to grow. Keep it in the dark for a long time, and it finally dies even when water and soil are supplied. The leaves, therefore, are essential and require sunlight in doing their work. Their complete work will be considered later.

HOW THE PLANT GETS ITS FOOD FROM THE SOIL

When seeds germinate, the lower end of the caulicle, which becomes the root, bears large numbers of root-hairs. Inside the root-hairs is protoplasm and cell sap. These root-hairs grow among the soil particles which lie covered over with a thin film of moisture. It is this moisture that is taken up by these root-hairs, and in it is a small amount of mineral matter in solution which helps to sustain the plant. The transmission of soil water through the delicate cell walls of these root-hairs is known as *osmosis*.

GERMINATION OF SOME OF THE COMMON GRAINS

Make a special study of corn, wheat, and buckwheat. Take three plates and put moist sand in each to a depth of about half an inch. Spread over this a piece of damp cloth. Put in No. 1, one hundred grains of corn; in No. 2, the same number of grains of wheat; and in No. 3, the same number of grains of buckwheat, peas, or beans. Cover each plate with another piece of damp cloth and invert another plate over each to prevent drying out. Keep in a warm room and do not allow the cloths to become dry. If one of the cloths be left hanging six or eight inches

over the side of the plate and dipping into a dish of water, the whole cloth will be kept moist by capillarity. Note the following points:

1. Changes in the size of the seeds during the first twenty-four hours.

2. In which variety germination seems most rapid.

3. The percentage vitality, that is, the number of seeds which germinate out of one hundred.

4. The nature of the coverings and their use. (Protection to the parts inside)

5. The parts of the seed inside. (Buckwheat, pea, or bean divides into two parts, which become greenish and are called seed leaves. Wheat and corn do not divide thus.)

6. The first signs of growth. A little shoot or tiny plant begins to develop at one end of the seed. Note which end bears this tiny plant.

7. Note the development of this embryo plant and the formation of stem and root.

8. Of what use is the bulky part of the seed? To answer this, let the pupils separate the white part of a kernel of corn, which is attached to the embryo plant, from the pulpy mass surrounding it. Set five such plants in moist sand and also five germinating seeds not so dissected. Pupils will discover that the mass surrounding the embryo is for the nourishing of the embryo plant. It is a little store of food prepared by the mother plant for the little ones that grow from the seeds. Note that it disappears as the plant grows.

To further show the great value of this stored plant food, put a large-sized pea in a pot of moist moss or sawdust for a few days. When it has germinated and its root is a couple of inches long, place the pea in a thistle

tube or small funnel, with the root projecting down the tube into a glass of water in which the funnel tube rests. Place all in a sunny window and note how much growth the plant is able to make without any food except that which the seed contained.

9. Note the development of the root and root-hairs. It is by means of these root-hairs that the plant absorbs moisture. The branching form of the root gives greater support to the plant and increased area for absorption of water by means of root-hairs.

To show the direction taken by the root and also by the shoot, take a glass jar with straight sides like a battery jar (a large fruit jar will do); line it inside with a layer of blotting-paper and then fill it with moist sawdust. Drop seeds of sunflower or squash down between the paper and the glass. The moisture from the blotting-paper will cause them to sprout, the shoot or stem always taking an upward direction and the root turning downward quite regardless of the position in which the seeds were placed.

10. Apply this study to seed planting: Plant seeds of wheat in four pots of soil, No. 1, half an inch deep; No. 2, two inches; No. 3, four inches; No. 4, six inches. Repeat this experiment, using buckwheat. What seeds are up first? What seeds last? Which are best after a week? After three or four weeks? From this experiment could you recommend a certain depth for the planting of wheat and buckwheat?

11. Does the kind of soil make any difference? To answer this have different pupils choose different soils, such as (1) coarse sand, (2) fine sand, (3) wet clay, (4) humus or leaf mould, (5) mixed soil or loam; and let each put in grains of wheat, two inches deep.

Allow five other pupils to plant seeds of buckwheat, under similar conditions. Treat all pots alike as to time of watering and quantity of water used on each and give them all equal light and heat. Note which come up first. Which are highest in one week, in two weeks, in four weeks?

12. This study may be continued in the garden by planting one plot each of corn, wheat, and buckwheat. Plots ten feet by twenty feet are large enough. Observe the rate of development in the plots. Which seems to mature most quickly? Which blossoms first? In what respect are the leaves of these plants alike or unlike? How do the stems differ?

Examine the blossoming and seed formation. When the grains are ripe, collect a hundred of the best looking and most compact heads of each grain and also a hundred of the smallest heads of each. Dry, shell, and store the two samples of each grain in separate bottles. These samples are for planting the following spring.

13. To show the need of moisture in germination: Fill two flower-pots or cans with dry sand; put seeds of sunflower in each, covering them an inch deep. Put water in one pot and none in the other. Examine both pots after two or three days.

14. To show that heat is needed for germination of seeds: Plant sunflower seeds in two pots as above; place one in a warm room and the other in a cold room or refrigerator; water both and observe result in three days.

15. To show that air is necessary for germination: Fill a pint sealer with hydrogen (the gas collected over water in the usual way, as shown in any Chemistry text-book). Put a few sunflower seeds in a small sponge or wrap them loosely in a piece of soft cloth. Keeping the mouth of the

jar, which has been inverted over water and filled with hydrogen, under the surface of the water, introduce the sponge containing the seeds, by putting it under the water and pushing it up into the jar. Seal the jar without letting the gas get out. Put some seeds in another jar in a wet sponge and leave the jar uncovered. Compare results after several days.

Here is a second experiment to prove this. Boil some water in a beaker in order to drive out all the air, put a few grains of rice in the water, and then add enough oil to make a thin covering on the water. This covering will prevent air from mixing with the water again. Put some rice in a second beaker without boiling or adding the oil. Leave the beakers side by side in a warm room for a week. The seeds will not germinate in the boiled water. It is not always easy to get rice that will germinate, but when it has been procured, the experiment is easy and very interesting. Any other seeds, such as those of pond lily and eel-grass, that germinate readily under water, will do as well as rice.

WEEDS

Pupils in this Form should learn to identify a large number of weeds and weed seeds. The collecting and mounting of weeds and weed seeds the previous summer and autumn will have helped to prepare them for this work. In the spring, when flower and vegetable seeds are coming up in the garden, it is often difficult for pupils to distinguish the weeds from the useful plants. To help in this work of distinguishing the good from the bad, the teacher should arrange for a plot having, say, ten rows, one row for each variety of weed selected. Each row should be designated by a number instead of a name. The identification of these growing weeds by name may be

given as a problem to the pupils. This plot should remain until the pupils have observed the manner of growth of each variety, the blossoming and seed formation, and then the root growth, as they are being uprooted previous to the ripening of the seed. Each pupil should prepare a brief description of each of the ten varieties studied, and make drawings of the plant and its parts, especially the leaf, flower, seed, and root. They should learn the best methods of eradication and add these in their notes. *Farm Weeds* will be of great value in such weed studies.

VINES

Suitable garden vines for study are climbing nasturtium, scarlet runner bean, and Japanese hop. Their growth and method of climbing should be compared with that of the sweet-pea and morning-glory already studied. Observe particularly the kind of leaves and their arrangement, also the flowers and fruit. Observe also the gourd family—melon, cucumber, and squash—their tendency to climb, and the nature of their flowers and fruit.

WILD FLOWERS

In schools where the studies with garden plants, such as have been indicated, can be carried on, there will not be as much time for the study of wild flowers as in those schools where no garden plants are available. A definite list of wild flowers for study should be arranged by the teacher early in spring.

The following are common in most parts of Ontario: squirrel-corn, Dutchman's breeches, blue cohosh, dog's-tooth violet, water-parsnip, catnip, and mallow. In each study observe the following points:

1. Description of leaves and flowers for identification.

2. Storing of food in underground parts.

3. Time of flowering. (Pupils of this Form should keep a flower calendar.)

4. Description of fruit and seeds and how these are scattered.

5. Their location, and the character of the soil where found.

Encourage the pupils to transplant a specimen of each from the woods to the school or home garden. Moist humus soil and partial shade are the best conditions for the growth of these wild wood flowers. Review the type lessons given already for Primary classes and apply the information thus gained to the observational study of the varieties of flowers named above.

PLANTING OF TREES, SHRUBS, AND HERBACEOUS PERENNIALS IN HOME AND SCHOOL GROUNDS

This work should be the outcome of the plans made in the winter. If each pupil does a little toward the carrying out of the scheme of planting, the grounds will soon be wonderfully improved. The teacher should guard against over-planting and arrange for the care of the shrubs and flowers during the summer holidays.

New varieties of herbaceous perennials, grown from seed planted the previous summer or procured from homes in the vicinity, should be introduced. As most herbaceous perennials become too thick after a few years, it is necessary to keep digging some out year by year, dividing and resetting them, and fertilizing the ground.

Native trees and shrubs should be placed so as to obscure undesirable views, such as closets and outbuild-

ings, rough fences, or bare walls. This principle in planting should be observed in the case of trees. Evergreen trees are particularly desirable as screens and shelters from cold winds. No planting should be done, on the other hand, that would shut out a good view of the school or obscure a beautiful landscape. Too frequently unused corners of the school ground are covered with weeds. Prevent this by putting trees there and also shrubs. Keep all centres open, and let the trees, shrubs, and flowering perennials be massed about the corners and along the sides. The informal method of planting is to be preferred to formal planting of designs. The Public School Inspector will provide a copy of a departmental circular on the *Improvement of School Grounds,* which should be carefully studied by every teacher.

SHADE TREES

Consider suitable varieties to plant for shade and for ornamental effects. White elm, hard and soft maple, white birch, pines, and spruces are among the best. Elms and maples are excellent trees for roadside or street planting, and should be about forty feet apart. Spruces and pines may be planted five or six feet apart along the north and west, to act as a wind break. Otherwise, evergreens are best when planted in triangular clumps. White birch is particularly ornamental against a dark background of evergreens. Specimen trees of horse-chestnut, beech, ash, and hickory are also desirable.

TRANSPLANTING

The best time for transplanting trees is in the autumn after the leaves have fallen, or in the spring before the buds have opened.

In planting a tree, the following points should be observed:

1. Preserve as much of the root system as possible, and trim off all broken or bruised portions.

2. Do not expose the roots to sun or wind while out of the ground. This is especially important in transplanting evergreens.

3. Reduce the top of the tree sufficiently to balance with the reduced root system.

4. Set the tree a few inches deeper than it was before transplanting.

5. Pack the best top soil closely about the roots, so as to exclude all air spaces, since these tend to dry the delicate roots.

6. If the ground is very dry, water should be used in planting; otherwise it is of no advantage. Water the trees thoroughly once a week in dry weather during the first season.

7. After planting, put a mulch or covering of fine straw, grass, or chips for two or three feet around the tree; or establish a soil mulch and keep down the grass by frequent cultivation. Grass roots dry out the soil.

8. In the case of deciduous trees, have the lowest limbs at least seven feet from the ground. Evergreens, however, should never be trimmed, but should have their branches right from the ground up—this uninterrupted pyramid form is one of their chief beauties.

ANIMAL STUDIES

SCALE INSECTS

SAN JOSÉ SCALE

Certain districts in Ontario and especially those bordering on Lake Erie have suffered from the ravages of this scale on apple, peach, pear, and other orchard trees. A hand lens should be used in studying these insects, observations being carried on from May to September.

Carefully examine the fruits and twigs of orchard trees for evidences of the presence of the scale, and learn to identify it and to recognize the damages resulting from its attacks.

Observe the almost circular flat scale of a grayish colour and having a minute point projecting upward at its centre. The young insects which emerge from underneath these scales in the spring crawl around for a time, then become stationary, and each one secretes a scale under which it matures. The mature males have two wings but the mature females are wingless. Note the withering of fruit and twigs due to the insects' attacks and the minute openings in the skin of the twig, made by the insertion of the sucking mouth parts.

Describe to the pupils how the insect was transported from Japan to America and how it is now spread on nursery stock. Give a brief account of its destructiveness in the orchards of Essex and Kent.

(Consult *Bulletin No. 153, Common Insects Affecting Fruit Trees and Fungus Diseases Affecting Fruit Trees*, Bethune & Jarvis, Department of Agriculture, Toronto, free.)

OYSTER-SHELL BARK-LOUSE

This is very common throughout the Province on apple and pear trees. Observe the unhealthy appearance of the leaves of the infested trees, the inferior quality of the fruit, and the gray scales shaped like tiny oyster-shells.

The means of destroying these pests should be discussed. The Bulletins named above give detailed information in reference to spraying and fumigation.

CUTWORMS

(Consult *Bulletin 52*, Department of Agriculture, Ottawa.)

Cutworms are the larvæ of medium-sized brown moths that fly at night. There are many species of cutworms, all of which are destructive to some forms of plants or grasses, grains, and vegetables.

The larvæ are rather thick, naked, worm-like forms. They burrow into the ground, but emerge at night to feed by cutting through the stems of tender plants or by feeding upon the leaves. For the most effective method of dealing with these refer to what is said on "Combating Garden Pests", Form II.

When a field is known to be infested with cutworms, it is a good plan to spread poisoned clover or cabbage leaves over the ground before the seed is planted.

WHITE GRUBS

White grubs are large, fat, white larvæ of June beetles. These beetles are the well-known large, brown, clumsy beetles that blunder into the house at night in May or June and drop with a thud upon the floor. Three

years are spent in the larval form, the grubs living underground and feeding on the roots of plants, especially the roots of grains and grasses.

Since they are found chiefly in fields recently ploughed from grass, they may be held in check by rotation of crops and by fall ploughing, which exposes the larvæ to the winter frosts.

In May or June, when the adults are feeding on the foliage of fruit and shade trees, spraying the trees with London purple is quite effective for destroying the beetles before they have laid their eggs among the roots of the grass.

Hogs destroy many larvæ by rooting in the soil to find them for food.

CRAYFISH

Search for the crayfish in streams and ponds. Why is the crayfish hard to find? Hard to capture?

Obtain a living crayfish from a pond or stream and place it in a jar of water or in an aquarium.

The crayfish should not be placed in an aquarium containing insects and small fish which are to be kept, as it is fierce and voracious.

The pupils should study the living animal, noting its habit of lurking under stones; the sweeping of the water with the feelers; the backward movement in swimming, produced by bending the tail sharply underneath the body; the walking by means of four pairs of legs, the great claws being used to turn the animal; the use of the great claws in seizing prey and holding food near the mouth; the movements of the small appendages under the front part of the animal and the water currents caused by these; the movements of the small appendages under the abdomen of the animal.

FRESHWATER MUSSEL

The freshwater mussel—"clam" as it is usually called by school-boys—may be found in almost any stream.

Place a mussel in the aquarium, and note the opening and closing of the valves of the shell; the hinge connecting the valves; the foot protruding from the shell; the movements by means of the foot; the mantle lobes lining the shell and visible at the open margins; the two siphons at the rear of the animal—water currents may be observed entering the upper and emerging from the lower of these. Infer uses for these currents. Touch the edge of the upper siphon and observe how quickly the shell is closed.

Compare the mussel with the snail as to movements and shell.

Compare also with the oyster and sea clam.

Examine empty shells and notice the pearly layer of the shell, the action of the hinge, and the marks on the shell to which the muscles for closing the shell were attached.

State all the means of protection that you have discovered the animal to possess.

BIRD STUDY

(Consult *Bulletin 218, Birds of Ontario in Relation to Agriculture*, Nash. Department of Agriculture, free.)

If the lessons in bird study which are prescribed for Forms I, II, and III have been successful, the pupils of Form IV should have a fair acquaintance with the habits of the common birds.

A very interesting exercise is to hold a trial upon those birds which are viewed with suspicion or which are openly condemned as objectionable neighbours. A pupil is

appointed to act as judge and other pupils give evidence. The evidence must be based upon the pupil's personal observations on the habits of the bird.

The following birds are named, and brief descriptions of their habits are given as suggestions for materials for bird trials:

Robin.—He steals small fruits, such as cherries, currants, etc. He is a cheerful, jolly neighbour, who sings sweetly. He eats great numbers of cutworms and white grubs.

Crow.—He robs the nests of other birds, and steals chickens, corn, and potatoes. He helps the farmer by killing cutworms, white grubs, grasshoppers, and other insects.

Woodpecker.—The members of this family are grievously persecuted because they are believed to injure orchard and shade trees by pecking holes in the bark from which to suck the sap. Careful observations tend to show that the trees are benefited rather than injured by this treatment. Woodpeckers are undoubtedly beneficial as destroyers of wood-borers and other obnoxious insects.

Crow-blackbird (bronzed grackle).—His habits are similar to those of the crow.

Owls.—All the owls are held in ill repute because of the crimes of a few members of the family. Very seldom does an owl steal a chicken; their food consists chiefly of mice, rats, squirrels, grasshoppers, and other field pests.

Hawks.—The hawks are unjustly persecuted for crimes of which they are seldom guilty. As a class they are beneficial, not injurious birds.

DIFFERENT ASPECTS OF NATURE STUDY

There is a knowledge of Nature which contributes to the earning of a living. This is the *utilitarian* aspect.

There is a knowledge of Nature which may be obtained in such a way as to develop the observing and reasoning powers and give a training in scientific method. This is the *disciplinary* aspect.

There is a knowledge which leads the pupil to perceive the beautiful in Nature, to enjoy it and so add to his happiness. This is the *æsthetic* aspect.

There is a knowledge of Nature which, through the life history of plant and animal, throws light on the pupil's own life, gives him an insight into all life in its unity, and leads him to look up reverently to the author of all life—through Nature up to Nature's God. This is the *spiritual* aspect.

Each of these aspects supplements, interprets, or enforces the others. He who omits or neglects any of these perceives but a part of a complete whole. Nature Study develops in the pupil a sympathetic attitude toward Nature for the purpose of increasing the joy of living. It leads him to see Nature through the eyes of the poet and the moralist as well as through those of the scientist.

Nature Study is concerned with plants, birds, insects, stones, clouds, brooks, etc., but it is not botany, ornithology, entomology, geology, meteorology, or geography. In this study, it is the spirit of inquiry developed rather than the number of facts ascertained that is important. Gradually it becomes more systematic as it advances until, in the high school, it passes over into the science group of studies.

ILLUSTRATIONS OF THESE ASPECTS

The simple observational lessons on The Robin, pages 96-7, form the bases for further study in more advanced classes. This bird as a destroyer of worms, beetles, etc., is a valuable assistant to the farmer as, indeed, are practically all birds in this Province. Birds such as the duck, goose, partridge, etc., are valuable as food, and laws are made to protect them during certain seasons.

The training in inference which a pupil receives in studying the parts of a plant or an animal and the adaptation of these parts to function is valuable. He studies the plant and the animal as living organisms with work to do in the world, and learns how what they do and their manner of doing it affect their form and structure.

The short, curved, and slightly hooked bill of the hen and her method of breaking open a pea pod or splitting an object too large to swallow shows the bill to be a mallet, a wedge, or a pick as the case may be. A study of the bills of the duck, woodpecker, and hawk will reveal the method by which each gets his food and how the organ is adapted to its purpose. Similar studies of the feet and legs of birds will make the idea of adaptation increasingly clear.

Literature is rich with tributes to the songs of the birds. The thoughts and feelings aroused or suggested by these songs are the topics of much of the world's enduring poetry. Longfellow, in his "Birds of Killingworth" (*Tales of a Wayside Inn*) sings exquisitely of the use and beauty and worth of birds. Shelley, in his "Skylark", describes in glowing verse "the unbodied joy" that "singing still dost soar and soaring ever singest".

Wordsworth hears the blithe new comer, the Cuckoo, and rejoices

> **Though babbling only to the vale**
> **Of sunshine and of flowers**
> **Thou bringest unto me a tale**
> **Of visionary hours.**

The life story of a bird throws light on our own lives, puts us in sympathy with the lives of others, teaches kindness, teaches the duties and responsibilities of the higher to the lower, teaches respect for all life.

Observe the helpless bird in its nest, helpless as a baby. See the care given by the mother and father to keep it warm till its down and feathers grow, to feed it till it is able to leave the nest. Watch the parents teaching it to fly by repeated short flights. Olive Thorn Miller in her *Bird Ways* gives a delightful sketch of the father robin teaching a young robin where to look for worms and how to dig them up. When that task was accomplished, his father began to give him "music lessons", that is, practice in imitating the Robin's song. Thus, the young bird was equipped to make a living and to enjoy life. The social life of birds, as they sing their matins, as they choose their mates, as they gather in flocks preparatory to migration, furnish many opportunities for indirect teaching on many of life's problems.

The Ontario Readers contain many poems that may be used in connection with the Nature Study lessons. To supplement the observational studies of birds, read from the Third Reader, "The Robin's Song", "The Red-winged Blackbird", "The Sandpiper", "To the Cuckoo", "Bob White", "The Lark and the Rook", "The Poet's Song".

In the Third Reader, the lessons on "The Fountain", "The Brook", "The Tide River", and "A Song of the

Sea" form a group that can be used in connection with lessons in geography. "A Song for April", "An Apple Orchard in the Spring", "The Gladness of Nature", "The Orchard", "A Midsummer Song", "Corn-fields", "The Corn Song", "The Death of the Flowers", "The Frost", "The Snow-storm", make another group to accompany a study of the seasons. A similar group may be selected from the Fourth Reader.

The pupil who has made a study of a "brook" as a lesson in geography and defined it as "a small natural stream of water flowing from a spring or fountain" will, if he studies the following lines from Tennyson's "The Brook" and perceives by careful observation the descriptive accuracy and aptness of the words in italics, realize that the poet sees much that the geographer has not included in his definition.

I *chatter* over stony ways,
In little sharps and trebles,
I *bubble* into eddying bays,
I *babble* on the pebbles.

. . . . . .

I *slip*, I *slide*, I *gloom*, I *glance*,
Among my skimming swallows;

. . . . . .

I *murmur* under moon and stars.

. . . . . .

I *linger* by my shingly bars,
I *loiter* round my cresses.

Correlations such as these add greatly to the pupil's interest in this subject.

Given a teacher with a love of out-of-door life, with observant eyes and ears, and the spirit that sympathizes with children's curiosity and stimulates inquiry, Nature Study will be a joy and an inspiration to pupils.